FINAL REPORT

STOCK IDENTIFICATION OF COLUMBIA RIVER CHINOOK SALMON AND STEELHEAD TROUT

Carl B. Schreck, Principle Investigator
Hiram W. Li
Randy C. Hjort, Project Leader
Cameron S. Sharpe

Other Staff

Kenneth P. Currens
Patrick L. Hulett
Steven L. Stone
Sylvia B. Yamada

Oregon Cooperative Fisheries Research Unit
Oregon State University
104 Nash Hall
Corvallis, Oregon 97331

Submitted to
United States Department of Energy
Bonneville Power Administration
Division of Fish and Wildlife
P.O. Box 3621
Portland, Oregon 97208

Gerald R. Bouck, Project Officer

Agreement No. DE - A179 - 83BP13499

Project 83 - 451

Aug 1, 1986

TABLE OF CONTENTS

TABLE OF CONTENTS

EXECUTIVE SUMMARY

For the first time genetic similarities among chinook salmon and among steelhead trout stocks of the Columbia River were determined using a holistic approach including analysis of life history, biochemical, body shape and meristic characters. We examined between year differences for each of the stock characteristics and we also correlated the habitat characteristics with the wild stock characteristics.

- The most important principle for managing stocks of Columbia River chinook salmon and steelhead trout is that geographically proximal stocks tend to be like each other. Run timing and similarity of the stream systems should be taken into account when managing stocks.

- There are similarities in the classifications derived for chinook salmon and steelhead trout.

- Steelhead trout or chinook salmon tend to be genetically similar to other steelhead or chinook stocks, respectively, that originate from natal streams that are geographically close, regardless of time of freshwater entry. The primary exception Lo this trend is between stocks of spring and fall chinook in the upper Columbia River where fish with the different run timings are dissimilar, though geographically proximate stocks within a run form are generally very similar.

- Spring chinook stocks have stronger affinities to other spring chinook stocks that originate in the same side of the Cascade Range than to those spring chinook stock: spawned on the other side of the Cascade Range. Spring chinook from west of the Cascades are more closely

related to fall chinook than they are to spring chinook from east of the Cascades.

- Summer chinook can be divided into two main groups: 1) populations in the upper Columbia River that smolt as subyearlings and fall chinook stocks; and 2) summer chinook stocks from the Salmon River, Idaho, which smolt as yearlings and are similar to spring chinook stocks from Idaho.

- Fall chinook appear to comprise one large diverse group that is not easily subdivided into smaller subgroups. In general, upriver brights differ from tules by at least one locus.

- Steelhead stocks can be divided into two main groups: 1) those stocks found east of the Cascades; and 2) those stocks found west of the Cascade Mountains.

- Steelhead from west of the Cascades are divisable into three subgroups of closely related stocks: 1) a group comprised mainly of wild winter steelhead from the lower Columbia River; 2) Willamette River hatchery and wild winter steelhead; and 3) summer and winter hatchery steelhead stocks from both the lower Columbia and Willamette Rivers.

- Steelhead from east of the Cascades are separable into three subgroups of closely related stocks: 1) wild summer steelhead; 2) a group comprised mainly of hatchery summer steelhead stocks; and 3) other hatchery and wild steelhead from Idaho.

- Streams east and west of the Cascades can be differentiated using characters including precipitation, elevation, distance from the mouth of the Columbia, number of frost-free days and minimum annual air temperature.

- There are significant differences among the stocks of chinook salmon and steelhead trout for each of the meristic and body shape characters. Between year variation does not account for differences among the stocks for the meristic and body shape characters with the exception of pelvic fin ray number in steelhead trout.

- Characters based on body shape are important for discriminating between the groups of hatchery and wild steelhead stocks. We could not determine whether the basis for the differences were genetic or environmental.

- The reason for the variation of the characters among stocks is as yet unclear. Neutrality or adaptiveness has not been firmly demonstrated.

STOCK IDENTIFICATION OF COLUMBIA RIVER CHINOOK SALMON

AND STEELHEAD TROUT

INTRODUCTION

Stock identification is an accepted management tool in fisheries, particularly for species that return to their natal areas to spawn. For anadromous salmonids, the tendency to return to natal streams reduces gene flow and allows the individual stocks to adapt to specific stream systems.

The important concerns addressed by the stock concept include proper management of exploited fish populations (Radcliffe 1928; Royal 1953), protection of gene pools (Behnke 1972a; Gall 1972), and productivity of introduced and native fish populations (Ricker 1972; Reisenbichler and McIntyre 1977). The maximum productivity of a complex river system should be achieved when several stocks are present, each with co-adapted gene systems for maximum fitness (Loftus 1976). The ability to identify stocks provides opportunity for greater harvest of underutilized stocks while protecting stocks that are at low levels of abundance, (Larkin 1981; Altukhov and Salmenkova 1981; McDonald 1981).

Preservation of the gene pools is important for maintaining the genetic diversity and thus the adaptive potential of a species (Warren and Liss 1980). Wild stocks may be particularly important gene resources in view of the potential loss of genetic diversity through inbreeding and selection (Allendorf and Phelps 1980, Stahl 1983) and the possible lower vitality (Ihssen 1976, Thorpe 1980) of hatchery stocks. In theory, the productivity of introduced stocks is related to the degree of their adaptation to the recipient stream systems. Introduced stocks that are genetically similar to the native stocks should, by the same rationale, have a higher survival rate than stocks that are dissimilar. The failure of some introduced stocks can be attributed to poor adaptation (Cleaver 1968, Ricker 1972, Barns 1976, Saunders 1981). Introduced stocks could also potentially harm the native stocks through introgression and thus reduce the productivity of the wild stock (Reisenbichler and McIntyre 1977; Altuhkov 1981; Ryman and Stahl 1981).

The concerns addressed by the stock concept are particularly important to the Columbia River fisheries where many of the stocks have been lost or are at low levels of abundance because of overharvest, habitat degradation, or hydroelectric dams. In addition, the relationships among the stocks have been altered by hatchery production and transfers of stocks within the basin. In light of the susceptibility of salmonid stocks to genetic changes and loss of overall diversity (Thorpe et al. 1981), it is very important to identify the existing stocks and the relationships among the stocks in the Columbia River Basin.

Our purpose was to classify stocks of Columbia River steelhead trout (*Salmo gairdneri*) and chinook salmon (*Oncorhynchus tshawytscha*) in such a way as to assist fishery managers in selecting hatchery stocks and protecting wild stocks. The stocks we selected fit Larkin's (1972), definition of stock in that the members of each stock were from a common environment, they participate in a common gene pool and are recognized by management as a self perpetuating unit. We classified the stocks in a systematic way by utilizing a wide variety of genetically related characters and we explored the relationships between the stock characteristics and characteristics of the stream system. The genetically related characters provide an estimate of the total genome of each stock, and the relationships between the stocks and their stream characteristics will help fishery managers understand the potential environmental forces affecting the observed stock diversities.

The stock characteristics examined included life history, biochemical and morphological characters. The advantages and disadvantages of these characters for describing stocks of fish were discussed by Ihssen et al. (1981a). Similar studies, using a variety of characters, have been conducted on lake whitefish (*Coregonus clupeaformis*) (Loch 1974; Casselmann et al. 1981; Ihssen et al. 1981b), sockeye salmon (*O. nerka*) (Vernon 1957), and coho salmon (*O. kisutch*) (Hjort and Schreck 1982). Each of the characters evaluated by us have a genetic basis. Allendorf and Utter (1979) have reviewed evidence for the genetic basis for biochemical characters. The biochemical characters that we used in this study are given in Table 1. Biochemical analysis for some of the Columbia River stocks have been previously completed by Milner et al. (1980) and Milner et al. (1983). The life history characters include time of entry into fresh water and time of spawning. Hypotheses have been proposed to explain the significance to stock fitness of life history characters for both Atlantic salmon (*Salmo salar*) (Schaffer and Elson 1975) and steelhead trout (Withler 1966; Biette et al. 1981). Ricker (1972) has reviewed the evidence for a genetic component in time of entry into fresh water for chinook. Evidence for a genetic component in time of spawning has been given by

Table 1. Abbreviations for the enzyme systems used to characterize stocks of Columbia River chinook salmon and steelhead trout. The enzyme systems marked with asterisks were included in the cluster analysis of the steelhead stocks and the enzyme systems marked with a plus sign were included in the cluster analysis of the chinook stocks. The other enzyme systems were surveyed but not included in the analysis because of low variability or incomplete data.

ENZYME SYSTEM *	ABBREVIATION
Aconitate hydratase * +	AH
Adenosine deaminase	ADA
Alcohol dehydrogenase +	ADH
Aspartate aminotransferase	AAT
Creatine kinase	CK
Dipeptidase * +	DPEP
Glucose-6-phosphate isomerase * +	GPI
Glutathione reductase	CR
Glucose-6-phosphate dehydrogenase	G6PDH
Glycerol-j-phosphate dehydrogenase *	G3PDH
Hydroxyacylglutathione hydrolase	HAGH
L-Iditol dehydrogenase	IDDH
Isocitrate dehydrogenase *	IDH
L-Lactate dehydrogenase * +	LDH
Malate dehydrogenase * +	MDH
Malate dehydrogenase (NADP+) *	MDHp
Mannose-6-phosphate isomerase * +	MPI
Thosphoglucomutase	PGM
Phosphogluconate dehydrogenase	PGDH
Phcsphoglycerate kinase	PGK
Proline dipeptidase	PDPEP
Superoxide dismutase * +	SOD
Triose-phosphate isomerase	TPI
Tripeptide aminopeptidase * +	TAPEP

Donaldson (1970) for chinook salmon, while Garrison and Rosentreter (1981), and Ayerst (1977) have provided similar evidence for steelhead trout .

Sixteen morphometric and nine meristic characters were measured. Riddel et al. (1981) and Taylor and McPhail (1985a) demonstrated a genetic basis for body shape and fin length in Atlantic salmon and coho salmon respectively. A plausible adaptive basis for these characters was provided by Riddell and Leggett (1981) and Taylor and McPhail (1985b) for Atlantic salmon and coho salmon respectively. A genetic basis has also been established for number of vertebrae (Winter et al. 1980), scales in the lateral series (Winter et al. 1980), scale rows (Neave 1944), gill rakers (Smith 1969), branchiostegals (MacGregor and MacCrimmon 1977), and fin rays (MacGregor and MacCrimmon 1977) in the steelhead-rainbow series. Ricker (1972) hypothesized that the meristic characters of salmonids probably have both genetic and environmental components. While it is difficult to determine the importance of these phenotypic characters to the fitness of the stocks, meristic characters could still have, through selection or pleiotropic effects a bearing on fitness (Barlow 1961) and thus may serve as genetic markers. The heritability of meristic characters is extremely high (Fred Allendorf, pers. comm.)

The stocks of steelhead trout and chinook salmon that were identified for inclusion in this study included most of the major stocks in the Columbia River so that comparisons could be made among geographical areas, among stream types and between hatchery and wild stocks (Figures 1-4 and Tables 2 and 3).

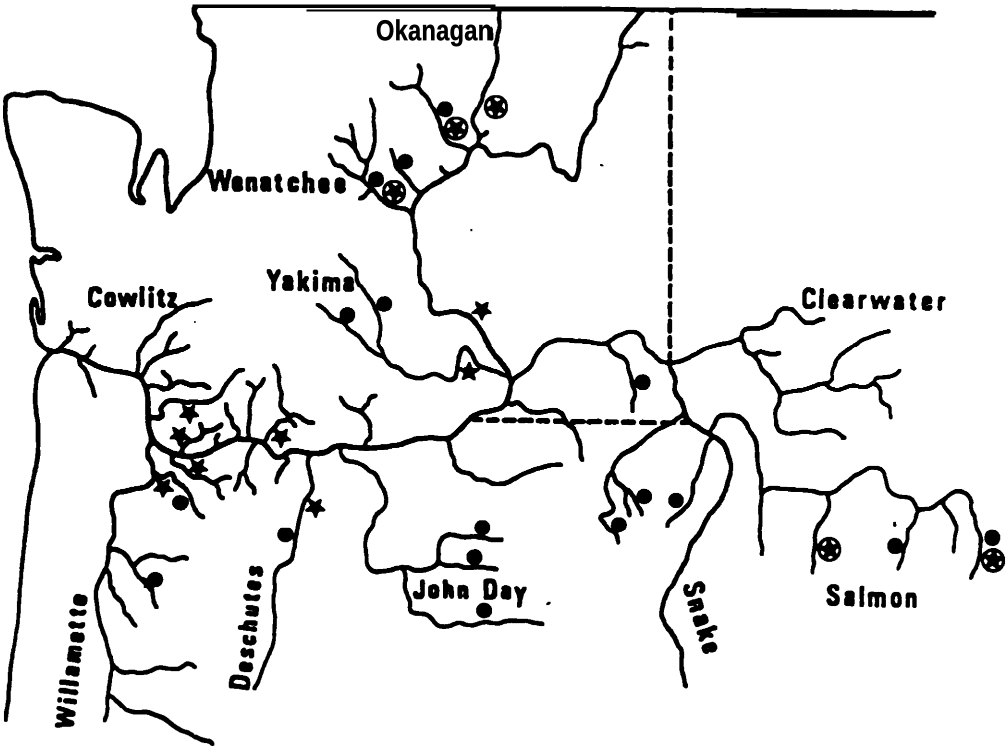

Figure 1. Sampling sites in Oregon, Washington and Idaho of wild spring (dots), summer (circled stars) and fall (stars) chinook salmon stocks.

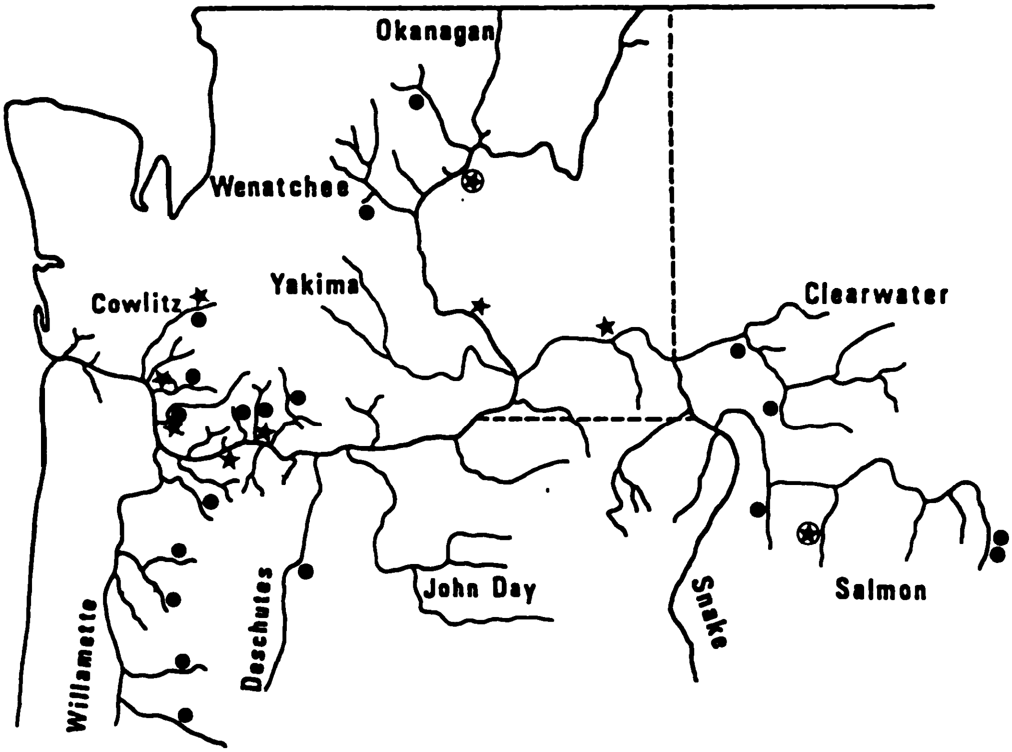

Figure 2. Sampling sites in Oregon, Washington and Idaho of hatchery spring (dots), summer (circled stars) and fall (stars) chinook salmon stocks.

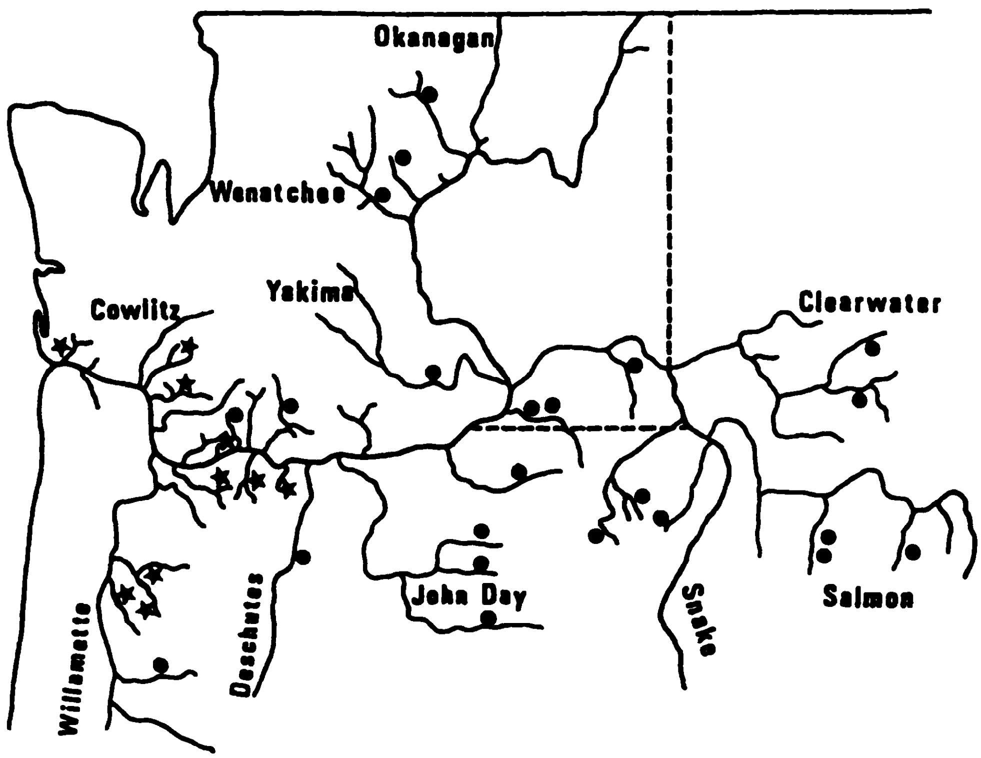

Figure 3. Sampling sites in Oregon, Washington and Idaho of wild summer (●) and winter (*) steelhead trout stocks.

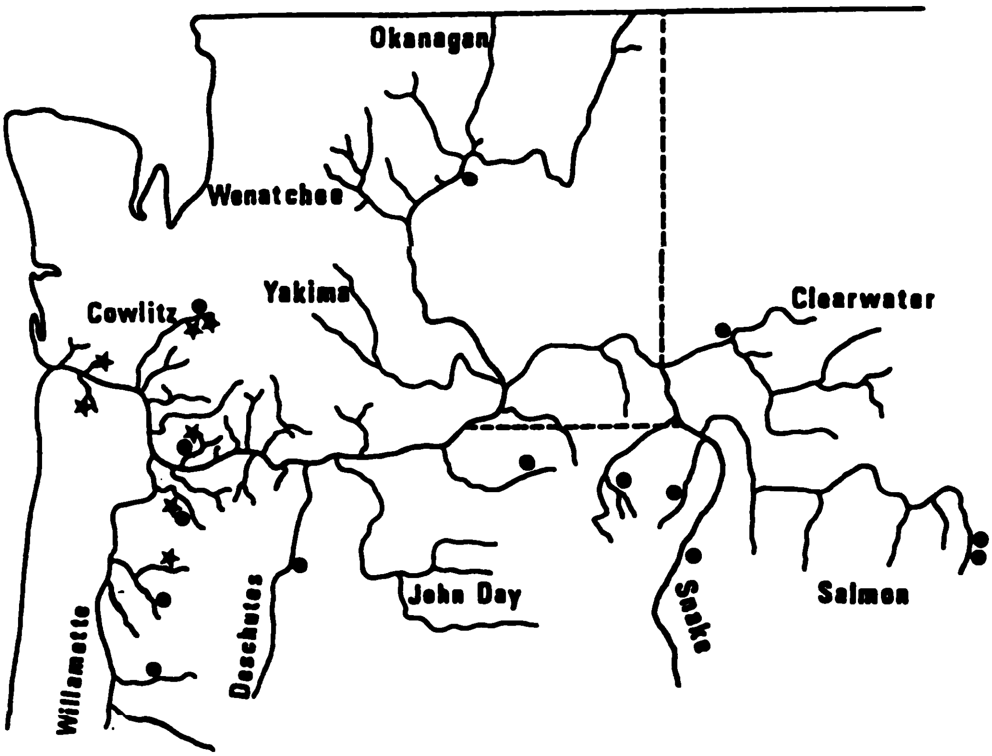

Figure 4. Sampling sites in Oregon, Washington and Idaho of hatchery summere (●) and winter (★) steelhead trout stocks.

Table 2. Chinook stock names and codes used in Figure 7. Abbreviations for form are fall (F), summer (SU), and spring (SP).

STOCK CODE	STOCK NAME	FORM	CLUSTER
BONNFH	BONNEVILLE HATCHERY	F	6
CARSPH	CARSON HATCHERY	SP	1
CLAKFW	CLACKAMAS RIVER	F	7
COLLPW	COLLOWASH RIVER	SP	7
COWLFH	COWLITZ HATCHERY	F	5
COWLPH	COWLITZ HATCHERY	SP	5
DEXTPH	DEXTER HATCHERY	SP	7
DSCHFW	DESCHUTES RIVER	F	5
EAGLPH	EAGLE CREEK HATCHERY	SP	7
EFSAPH	EAST FRK SALMON R. STK	SP	3
ENTIPW	ENTIAT RIVER	SP	2
GDRDPW	GRANDE RONDE RIVER	SP	2
HANFFW	HANFORD REACH	F	5
IMNAPW	IMNAHA RIVER	SP	2
JNDAPW	JOHN DAY RIVER	SP	1
JOHNSW	JOHNSON CREEK	SU	3
KALAFH	KALAMA HATCHERY	F	6
KALAFW	KALAMA RIVER	F	5
KLICFW	KLICKITAT RIVER	F	5
KLICPH	KLICKITAT HATCHERY	SP	4-5
KOOSPH	KOOSKIA HATCHERY	SP	3
LEAVPH	LEAVENWORTH HATCHERY	SP	3
LEWIFH	LEWIS HATCHERY	F	5
LEWIFW	LEWIS RIVER	F	5
LWTSPH	LIT. WHT SALMON HATCH.	SP	4
MARIPH	MARION FORKS HATCHERY	SP	4
MCALSH	McCALL HATCHERY	SU	3
MCKEPH	McKENZIE HATCHERY	SP	7
MSLMPW	MIDDLE FRK SALMON RIVER	SP	1
MTHWPW	METHOW RIVER	SP	3
MTHWSW	METHOW RIVER	SU	6
NACHPW	NACHES RIVER	SP	3
OKANSW	OKANAGAN RIVER	SU	6
PRRPFH	PRIEST RAPIDS HATCHERY	F	6
REDRPH	RED RIVER HATCHERY	SP	1
RNDBPH	ROUND BUTTE HATCHERY	SP	2
RPDRPH	RAPID RIVER HATCHERY	SP	3
SANDFW	SANDY RIVER	F	5
SAWTPH	SAWTOOTH HATCHERY	SP	3
SNAKFH	SNAKE RIVER STOCK	F	5
SPEEPH	SPEELYAI HATCH. (LEWIS)	SP	1
SPRGFH	SPRING CREEK HATCHERY	F	6
SSNTPH	SOUTH SANTIAM STOCK	SP	7
THOMPW	THOMAS CREEK	SP	7
TUCNPW	TUCANNON RIVER	SP	4
VALLPW	VALLEY CREEK	SP	1
VALLSW	VALLEY CREEK	SU	3
WALOPW	WALLOWA LOSTINE	SP	2
WARMPH	WARM SPRINGS HATCHERY	SP	1
WASHFW	WASHOUGAL RIVER	F	5
WELLSH	WELLS DAM HATCHERY	SU	6
WENTPW	WENATCHEE RIVER	SP	2
WENTSW	WENATCHEE RIVER	SU	6
WNTHPH	WINTHROP HATCHERY	SP	1
YAKIFW	YAKIMA RIVER	F	6-7
YAKIPW	YAKIMA RIVER	SP	1

Table 3. Steelhead stock names and codes used in Figure 14. Abbreviations for form are winter (W) and summer (S).

STOCK CODE	STOCK NAME	FORM	CLUSTER	STOCK CODE	STOCK NAME	FORM	CLUSTER
BEAVWH	BEAVER CREEK HATCHERY	W	4	MCKESW	McKENZIE RIVER	S	4
BGCRWH	BIG CREEK HATCHERY	W	6	METHSW	METHOW RIVER	S	2
BGCWSW	BIG CANYON/COTTONWOOD CR	S	1	MISSSW	MISSON CREEK	S	1
CALAWW	CALAPOOYA RIVER	W	5	MSLMSW	MIDDLE FRK SALMON RIVER	S	1
CHAMWH	CHAMBERS CREEK STOCK	W	4	PAHSSH	PAHSIMEROI STOCK	S	3
CHMBSW	CHAMBERLAIN CREEK	S	1	RNDBSH	ROUND BUTTE HATCHERY	S	2
COWEWW	COWEEMAN RIVER	W	4	SANDWW	SANDY RIVER	W	4
COWLWH	COWLITZ HATCHERY	W	6	SAWTSH	SAWTOOTH HATCHERY STOCK	S	2
CSKMSH	COWLITZ HATCH.(SKAMANIA)	S	6	SCSHSW	SECESH RIVER	S	1
DSCHSW	DESCHUTES RIVER	S	1	SELWSW	SELWAY RIVER	S	3
DWORSH	DWORSHAK HATCHERY	S	3	SHBRSW	SHEEP/BARGAMIN CREEKS	S	1
EAGBWH	EAGLE CR. HATCH(BIG CR.)	W	6	SSNTSH	SOUTH SANTIAM HATCHERY	S	6
EAGLWH	EAGLE CR. HATCH.(NATIVE)	W	6	TCHTSW	TOUCHET RIVER	S	1
ENTISW	ENTIAT RIVER	S	1	THOMWW	THOMAS CREEK	W	5
FIFTWW	FIFTEENMILE CREEK	W	1-2	TOUTWW	TOUTLE RIVER	W	4
GDRDSW	GRANDE RONDE RIVER	S	1	TUCNSW	TUCANNON RIVER	S	1
GRAYWW	GRAYS RIVER	W	4	UMATSH	UMATILLA HATCHERY	S	2
HAMIWW	HAMILTON CREEK	W	4	UMATSW	UMATILLA RIVER	S	1
HELLSH	HELLS CANYON STOCK	S	2	WALLSW	WALLA WALLA RIVER	S	1
HOODWW	HOOD RIVER	W	4	WALOSH	WALLOWA HATCHERY	S	2
HORSSW	HORSE CREEK	S	3-4	WALOSW	WALLOWA LOSTINE	S	2
IMNASW	IMNAHA RIVER	S	1	WASHWH	WASHOUGAL HATCHERY STOCK	W	6
IMNASH	IMNAHA HATCHERY	S	2	WELLSH	WELLS DAM HATCHERY	S	2
JNDASW	JOHN DAY RIVER	S	1	WENTSW	WENATCHEE RIVER	S	1
JOHNSW	JOHNSON CREEK	S	1	WILYWW	WILEY CREEK	W	5
KLICSW	KLICKITAT RIVER	S	4	WINDSW	WIND RIVER	S	4
LEABSH	LEABURG HATCHERY	S	6	WSKMSH	WASHOUGAL HATCH.(SKAMANIA)	S	6
LOCHSW	LOCHSA RIVER	S	3	YAKISW	YAKIMA RIVER	S	1
MARIWH	MARION FORKS HATCHERY	S	5				

We calculated a measure of phenotypic similarity and used cluster analysis to display the relationships among the stocks. Because cluster analyses are arbitrary (Blackith and Reyment 1971), we used two clustering strategies to group phenotypically similar stocks. We wanted to determine if similar types of streams produce phenotypically similar stocks. Each cluster of phenotypically similar stocks was characterized by determining environmental characteristics common to the stream systems of the stocks in that cluster.

METHODS

We evaluated characters for hatchery and wild stocks of steelhead trout and chinook salmon from the Columbia River Basin in Oregon, Washington and Idaho. The history of each stock has been reviewed by Howell et al. (1985a and b). Based on their information we classified the stocks as wild (reproducing in streams with little or no record of stock transfers into the area of collection), hatchery stocks, introduced wild stocks (stocks with a history of receiving fish from another stream system), and introduced hatchery stocks (stocks in hatcheries with a history of receiving fish from another stream system). These classifications helped us to determine whether the characteristics reflected environmental factors or introgression of foreign genotypes.

Morphological Characters

Twenty fish from each sample were stored frozen for later analysis. Scales in the lateral series were counted on the left side in the second row above the lateral line, starting with the anterior-most scale and terminating at the hypural plate. Scales above the lateral line were counted from the fourth scale anterior to the insertion of the dorsal fir- to the lateral line. Anal rays were counted and did not include the short rudimentary anterior rays, and branched rays were counted as one. The number of gill rakers on the upper portion of the left first arch was recorded. Alizarin red was used to highlight rudimentary gill rakers. The number of branchiostegal rays on the left side was recorded. Vertebral counts, made on X-ray plates, included the last three upturned centra. Trout were examined for the presence of basibranchial teeth. The morphometric measurements followed those of Casselman et al. (1981) except for head width and snout to anterior insertions of the pectoral and pelvic fins which followed Riddell and Leggett (1981). We also measured the distance from the snout to the anterior insertion of the anal and dorsal fins.

Landmark points on the fish were highlighted, when necessary, using insect pins (eg. fin insertions) or small strips of white paper (eg. end of maxillary) and each fish was arranged and photographed on a flat surface with a ruler included in each frame. We then used a digitizer to record the X - Y coordinates of each landmark on all photographs. We accounted for differences in magnification by using a known distance on the ruler in each photograph to convert photograph X - Y coordinates to "real" X - Y coordinates. The various measurements were then calculated using the Pythagorean Theoreom and the coordinates of the appropriate landmark points. We included both classical and truss-type measurements similar to those found in Winans (1984) (Figures 5 and 6). Regression formulas were used to adjust the body shape measurements of each fish to a common fork length. Regression slopes of each measurement were calculated for each stock because there were differences among the stocks and so a common slope for each measurement could not be used.

We determined the effects of condition factor on morphometric

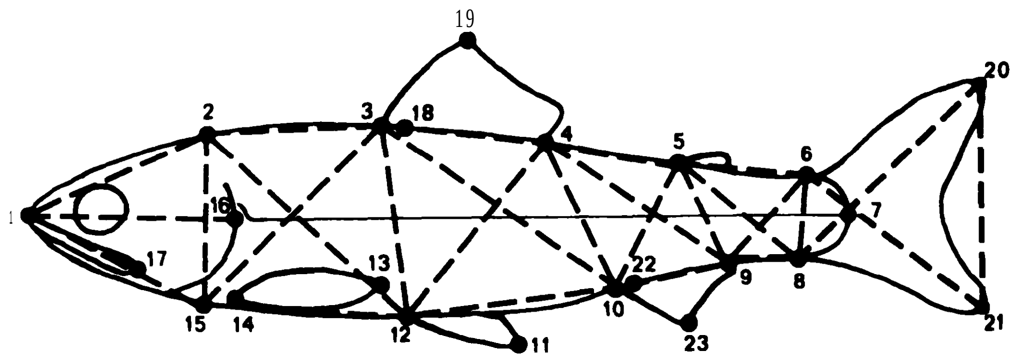

Figure 5. Representitive juvenile salmonid showing truss-type body measurements (dashed lines). Landmark points are numbered.

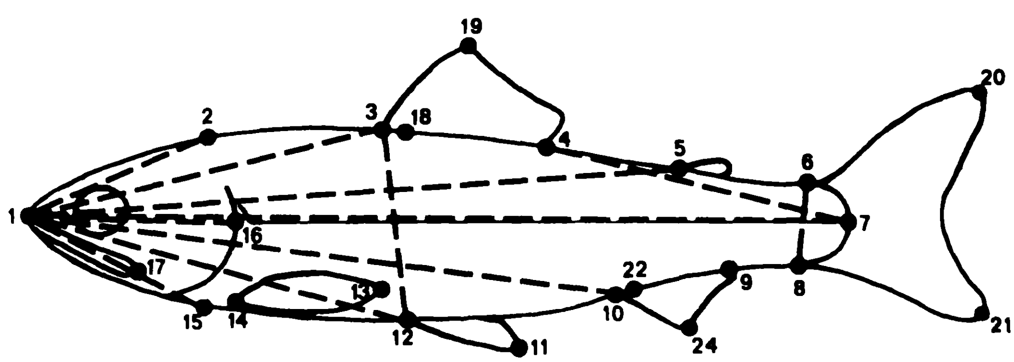

Figure 6. Representitive juvenile salmonid showing classical body measurements (dashed lines). Landmark points are numbered.

measurements of juvenile steelhead trout and juvenile chinook salmon to determine which morphometric characters are invalid for comparing fish from different environments (eg. hatchery vs. wild). We made morphometric measurements on Alsea hatchery steelhead trout and Willamette hatchery spring chinook that had been treated in one of two ways. We sampled the fish while they were on a feeding schedule comparable to that of most hatcheries. A second group of fish was starved starting at the same time that the first group of robust fish was sampled. When these starved fish reached a condition factor approximating that of wild fish, they too were sampled. This produced fed and starved groups of approximately the same average length. We had three different size groups for steelhead and four different size groups for chinook salmon. The size group ranged from fingerling (approximately 60 mm) to smolt size (approximately 130 mm) to cover the range of sizes used in our samples. The morphometric measurements were determined using the digitizer board and the methods listed above. We used analysis of covariance with the standard length as the covariate to adjust the values for differences in length within each size group and then tested for equality of the two treatments.

Several stocks of wild fall and wild summer chinook were captured in the natal streams and then fed in small concrete ponds at Willard National Fish hatchery to increase their size. Fall and summer chinook migrate from their natal streams before they are large enough for electrophoretic and morphometric analyses (about 75 mm). The stocks reared at Willard National Fish Hatchery were Clackamas, Sandy, Washougal, Klickitat and Hanford Reach fall chinook and Wenatchee, Methow and Okanagan summer chinook.

Electrophoresis

White muscle (1 cm^3 from the anterior epaxial section of each fish), liver and eye samples were cut from those fish that were not used for meristic and morphological evaluation. Sample sizes ranged from 24 to 158 for steelhead and 22 to 194 for chinook. The tissue samples were homogenized with 2-3 drops of water and then centrifuged to clear the supernatent. The methodology for the starch gel electrophoresis of the supernatent followed that of Utter et al. (1974) and Allendorf et al. (1977). The nomenclature for the enzyme systems (Table 1) analyzed in this study followed that of Allendorf and Utter (1979).

Life History

The life history characters we used were time of entry into fresh water and time of peak spawning. We estimated these parameters by reviewing Howell et al. (1985a and b) and through interviews with district biologists and hatchery managers. We stratified the time of entry into fresh water and the peak spawning times into 2-week segments.

Environmental Data

The stream characteristics evaluated included distance from the mouth of the Columbia to the spawning grounds, stream basin area above the spawning ground, gradient, precipitation, land form category, geological category, vegetation type, soil type, and elevation of the spawning area. To separate the populations that have short and long swimming distances to the spawning areas, we measured the distance from the mouth of the Columbia to the spawning grounds in each stream system.

Gradients from the mouth of the stream system to the upper limit of spawning and elevation of the spawning area were determined as a basis for estimating the difficulty of the spawning migration. We measured the stream elevations and distances on United States Geological Survey quadrangle maps. Precipitation, land form category, geological category, vegetative type and soil type were obtained from atlases (Fulton 1968 and 1970, Highsmith 1973, Loy et al. 1976).

We obtained temperature data from hatchery records to help interpret the meristic counts for the hatchery stocks. The average temperature for the first month of incubation was used because previous studies have indicated that this time is a period during ontogeny when meristic features may be most sensitive to the effect of temperature (Taning 1952).

Statistics

We calculated averages for the morphological characters and enzyme gene frequencies for each stock, and used analysis of covariance to determine whether meristic and body shape characters can be used to discriminate among the stocks after the correlations with other meristic or body shape characters are taken into account. Each meristic or body shape character was tested with all of the other meristic or body shape characters used as covariates. These tests determined if a character is significantly different among stocks after the character is adjusted to a new mean by the covariates. We determined the correlation between stock characters and habitat characters. We limited our analyses to those relationships with correlation coefficients greater than 0.60.

While correlation coefficients less than 0.60 may be statistically significant, they account for only 36% of the variation and are thus impractical to use. Fin lengths were only used in the analyses involving wild stocks because fins are shortened by abrasions in hatchery samples. Body shape measurements were converted to common logarithms for the reasons listed by Misra and Ni (1983). We used T-tests and analysis of variance to determine if the morphological characteristics were significantly different between year classes of the same stock or among groups of stocks from the cluster analysis. For each of the morphometric characters we combined year classes and tested for differences among stocks to determine if the within stock variation or temporal variation was responsible for the differences among stocks. We standardized the characters of stocks ($z = 0$, $s = 1$) for the cluster analyses using the standard normal standardization. This standardization expresses the stock character as standard deviations from the character mean, thus giving equal weight to each character.

We calculated regression and correlation coefficients (Snedecor and Cochran 1967) between the meristic characters and the temperature data for hatchery stocks only. The levels of significance for the regression and correlation coefficients were also calculated as described by Snedecor and Cochran (1967). Individual enzyme gene frequencies were compared between stocks with the chi-square 2 x N (N= the number of isozymes in the enzyme system) contingency table (Snedecor and Cochran 1967). The comparisons were between year classes to determine the stability of isozyme gene frequencies through time. According to Cochran (1954), Chi-square tests should be limited to those enzyme systems with no expected values less than one and no more than 20% of the expected values less than five. In some of the tests we combined the values of the variant alleles in order to meet Cochran's (1954) criteria. If we were unable to meet the criteria, we did not include that particular test in our analyses. Because we conducted simultaneous multiple tests when comparing year classes, we adjusted the significance level by dividing the number of enzyme systems that were tested into 0.05 (the non-adjusted significance level) (Cooper 1968). For example, when comparing 1984 and 1985 Big Creek Hatchery winter steelhead, the chi-square expected values for five enzyme systems met Cochran's criteria and thus the adjusted significance level is 0.05/5 = 0.01.

We used cluster analysis programs to display similarities among stocks. One program, a nonhierarchical divisive cluster analysis, minimized the Euclidean distance between observations and the cluster means. In the other, a hierarchical agglomerative cluster analysis, correlation was used as the dissimilarity measure, and the clustering strategy was group average (see Sneath and Sokal [1973] or Clifford and Stephenson [1975] for terminology). Data were standardized to a mean of zero and a standard deviation of one in both programs. Complete data sets are needed for the cluster analysis programs, so we substituted data from neighboring stocks of the same form to replace missing biochemical data in Methow summer chinook, which had missing data for three enzyme systems, and South Santiam Hatchery summer steelhead which was missing data for one enzyme system.

Canonical variate analysis was used to investigate the relation among the clusters from the agglomerative cluster analysis (Clifford and Stephenson 1975). Canonical variate analysis produces canonical variables that project groups of multivariate data onto axes separating the groups as much as possible. We plotted the canonical variables against each other in two-dimensional space to determine the relationships among clusters and the discreteness of the clusters.

We calculated relative heterozygosity values from the electrophoretic data using the formula from Nei (1972):

$$\text{Heterozygosity} = 1 - \left(\frac{\Sigma x_i^2}{N}\right)$$

N = number of loci

x_i= frequency of the i^{th} allele in the population

These values are relative heterozygosity values since we only used the loci that were polymorphic for at least one population.

RESULTS

Stocks of Columbia River steelhead trout and chinook salmon can be classified into several broad groups of similar stocks. These classifications are based on a combination of electrophoretic, meristic, body shape, and life history characters (Tables A1-A9). We were able to determine the validity of these characters and to determine the correlations between these characters and habitat type. The groups of similar stocks in the Columbia River as determined by our analysis will be reported first, followed by the validation of characters and then the correlations between the stock characters and habitat type.

I. CHINOOK SALMON

A. Stock Classification

Stocks of Columbia River chinook consist of two main groups: 1) spring chinook from east of the Cascade mountains together with summer chinook from the Salmon River and 2) spring chinook from west of the Cascades together with summer chinook from the upper Columbia River and all fall chinook stocks (Figure 7). These two groups can be further subdivided into four and three subgroups or clusters, respectively.

One of the subgroups of spring chinook from east of the Cascades is comprised of hatchery and wild spring chinook that are widely distributed east of the Cascade Mountains (Cluster) in Figure

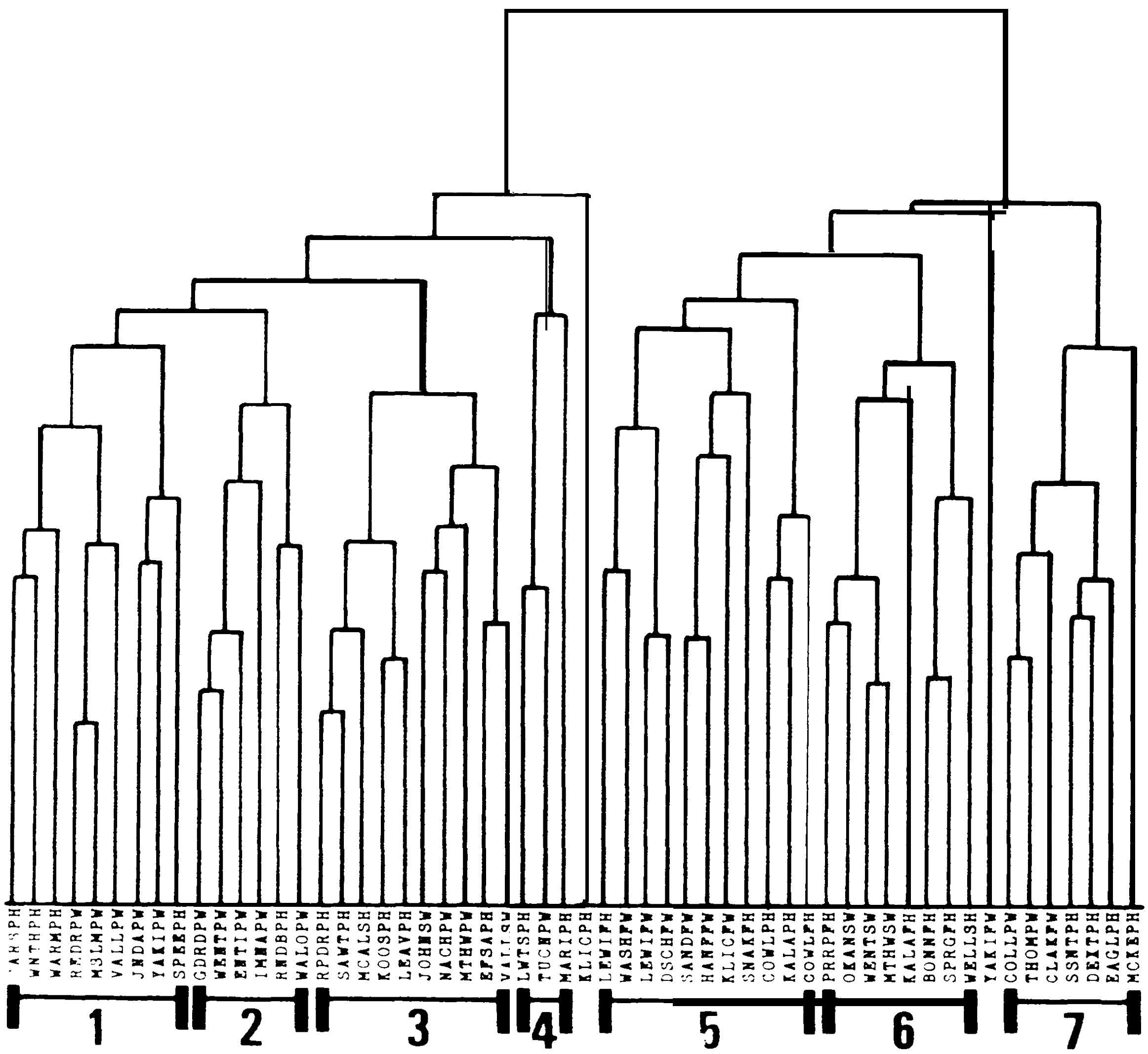

Figure 7. Chinook salmon cluster analysis using characters associated with body shape, meristics, biochemistry, and life history. Clustering strategy is correlation. See Table 2 for key to stock names.

7). This group is distinguished by the greatest average head depth, head width and pectoral ray counts and the lowest average number of gill rakers. The streams of the wild stocks in this cluster are located at higher elevations, in the upper reaches of the Columbia system and have colder climates compared to the other stream systems.

Wild spring chinook from the lower Snake and upper Columbia Rivers and the Round Butte Hatchery spring chinook comprise another subgroup of spring chinook from east of the Cascades (Cluster 2 in Figure 7). This group is distinguished by the highest average length of the anal fin base and interorbital width, the greatest frequency of the common tripeptide aminopeptidase allele, the lowest average number of branchiostegal rays, and the earliest average time of spawning. The streams of the wild stocks in this group have a steeper slope in the spawning area compared to the averages of the other groups.

Spring and summer chinook from Idaho are the most frequently encountered stocks in the third cluster in Figure 7. Three spring chinook stocks from the upper Columbia are also present. This subgroup of similar stocks consists of both hatchery and wild fish that are characterized by the smallest average head depth and the highest average number of scales in the lateral series, vertebrae, branchiostegal rays, anal fin rays, dorsal fin rays and gene frequencies of the common aconitate hydratase, superoxide dismutase and mannose phosphate isomerase alleles. The natal streams of the two wild stocks in this group had high land surface form values indicating steep, rugged terrain.

Another subgroup of stocks very similar to each other is composed of spring chinook from White Salmon Hatchery, Marion Forks Hatchery, and the Tucannon River (Cluster 4 in Figure 7). This group has the earliest average time of freshwater entry, the lowest average head length, pelvic fin ray number and frequency of the common glucose phosphate isomerase allele and the highest average caudal peduncle depth, caudal peduncle length and frequencies of the common alcohol dehydrogenase and dipeptidase alleles.

The second major group of chinook salmon in the Columbia River drainage can be divided into three subgroupings. One of these groups includes two hatchery spring chinook stocks from the lower Columbia river and hatchery and wild fall chinook from the Cowlitz River up to the Hanford Reach (Cluster 5 in Figure 7). This subgroup is characterized by the latest average time of adult entry into freshwater, the lowest average number of scales in the lateral series, scales above the lateral line and vertebrae and the lowest frequency of the common dipeptidase allele. In general, the streams of the five wild stocks in this group are located at low elevations near the mouth of the Columbia with gentle stream gradients in mild, moist climates.

Another grouping is composed of fall and summer chinook from the upper Columbia (Cluster 6 of Figure 7). This group is distinguished by the smallest average caudal peduncle depth, length of the anal fin base, head width, interorbital width and number of dorsal fin rays and the highest average number of scales above the lateral line. In addition, this group has the lowest frequencies of the common alcohol dehydrogenase, L-lactate dehydrogenase, tripeptide aminopeptidase and superoxile dismutase alleles. These stream systems are located further upstream, higher in elevation with steeper gradients than the stream systems of wild stocks from cluster 5.

The final subgroup is comprised of spring and fall chinook from the Willamette River system (Cluster 7 in Figure 7). This subgroup had the highest average values for head length, gill rakers and pelvic fin rays and the lowest average values for anal fin rays, pectoral fin rays and frequencies of the common aconitate hydratase, malate dehydrogenase and mannose phosphate isomerase alleles. All of these stocks are native to the Willamette River drainage except for the Clackamas wild fall chinook which may be either native or derived from hatchery strays.

The general conclusions that we would draw from the divisive cluster analysis and the canonical variate analysis are the same as the conclusions drawn from the agglomerative cluster analysis. According to the divisive cluster analysis, spring chinook from east of the Cascade Mountains were different than the spring chinook from west of the Cascade Mountains and the fail chinook and the summer chinook from the upper Columbia River. In addition, summer chinook from Idaho were similar to spring chinook from east of the Cascade Mountains. The main separation among the clusters was between cluster 1-4 and clusters 5-7 according to the canonical variate analysis.

There are some differences between hatchery and wild spring chinook stocks from east of the Cascade Mountains. Hatchery spring chinook stocks have smaller heads and greater counts of pelvic fin rays and branchiostegal rays compared to wild spring chinook stocks (Table 4).

Table 4. Mean values of specific characters with significant differences between hatchery and wild spring chinook from west of the Cascade Mountains. Estimated time of freshwater entry was averaged for each group.

CHARACTERS	HATCHERY	WILD
DATE OF FRESHWATER ENTRY	APRIL 18	MAY 8
HEAT LENGTH (1X1 6)	19.95	20.89
MAXILLARY LENGTH (1X17)	13.17	11.22
ANAL FIN BASE (9X10)	11.22	12.02
INTERORBITAL WIDTH	5.62	5.89
PELVIC FIN RAYS	9.16	8.86
BRANCHIOSTEGAL RAYS	15.96	15.64

The classification of chinook stocks using only electrophoretic characters is similar to the classification produced by all characters combined (Figures 7 and 8). The groups of similar stocks can be characterized as: 1) spring chinook from east of the Cascade Mountains; 2) spring chinook from Idaho; 3) a group of stocks that cannot be easily characterized; 4) Willamette River stocks; 5) fall and spring chinook from below Bonneville Dam; and 6) fall and summer chinook from the upper Columbia River and two Snake River summer chinook stocks.

Chinook stocks that have similar juvenile life histories tend to have similar body shape (Figure 9). Fall chinook and summer chinook from the upper Columbia River tend to be grouped together and spring chinook and summer chinook from Idaho are grouped together. The fall chinook and the summer chinook from the upper Columbia River outmigrate as subyearlings, while spring chinook and summer chinook from Idaho outmigrate as yearlings. The classification of chinook stocks using only meristic characters (Figure IO) produces the same major division of chinook stocks as the classification using all characters. The two main groups in Figure 10 are: 1) spring chinook from west of the Cascade Mountains, fall chinook and summer chinook stocks from the Upper Columbia River and 2) spring chinook from east of the Cascade Mountains and summer chinook from Idaho.

Stream system tends to be similar to neighboring stream systems in the same manner that a chinook stock tends to be similar to neighboring chinook stocks. Although the overall clustering patterns for wild chinook stocks (Figure 11) is different from the clustering pattern for the stream systems (Figure 12), both of the dendrograms

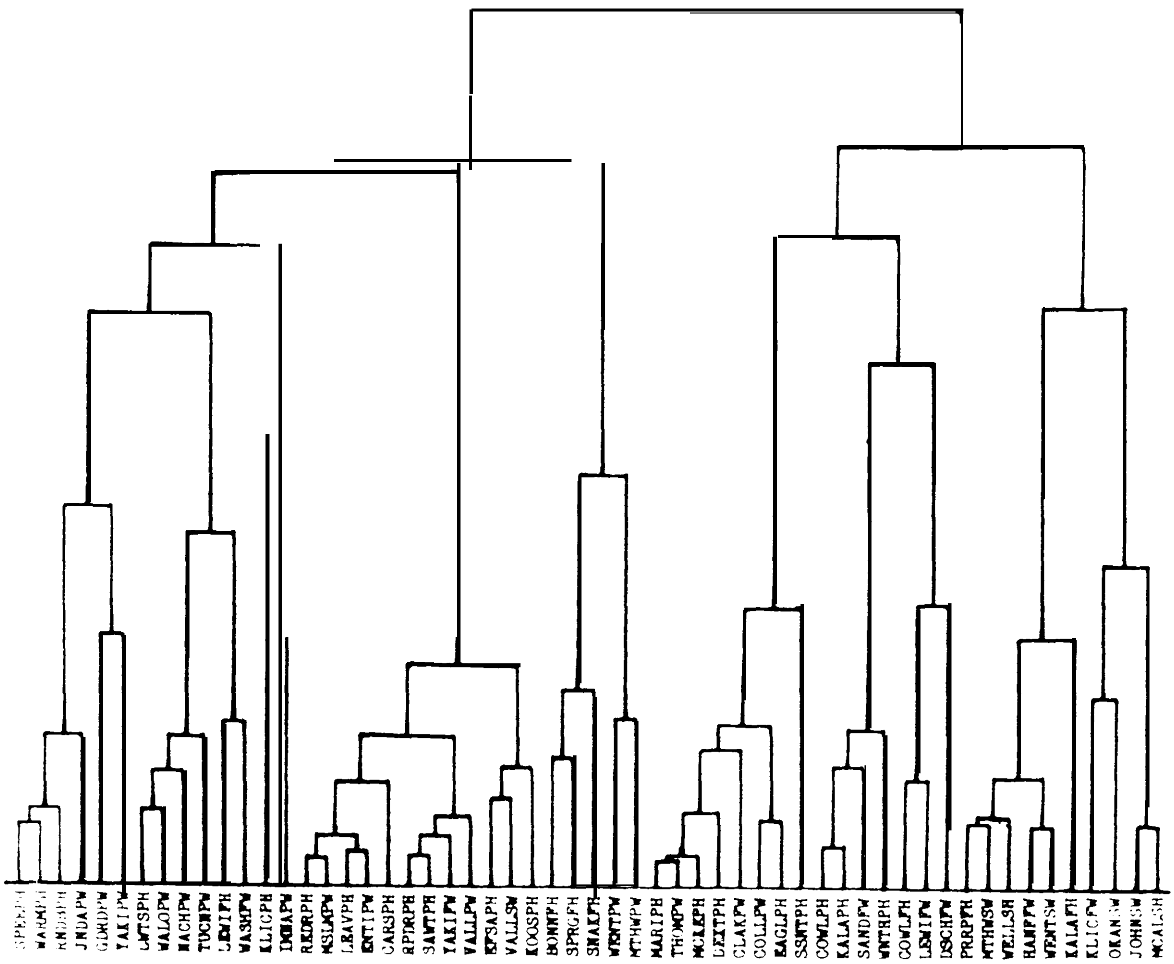

Figure 8. Chinook salmon cluster analysis wing biochemical characters. Clustering strategy is correlation. See Table 2 for key to stock names.

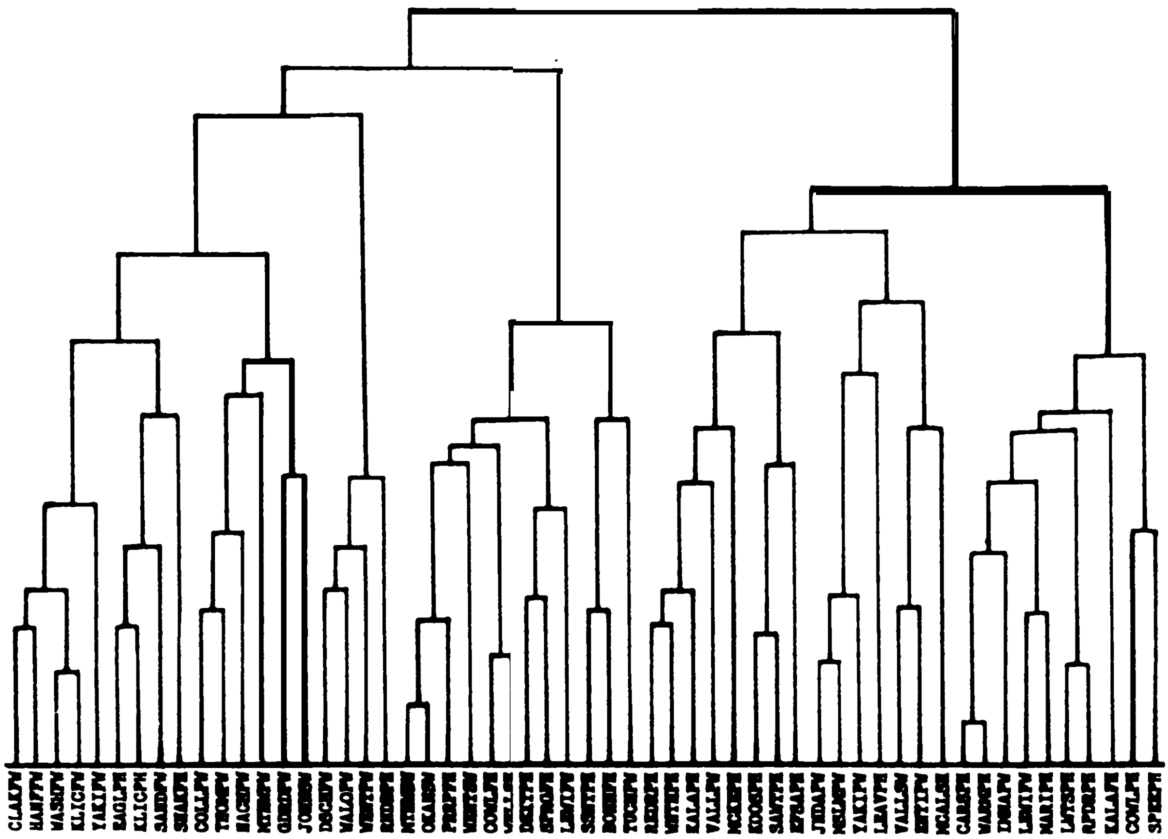

Figure 9. Chinook salmon cluster analysis using body shape characters. Clustering strategy is correlation. See Table 2 for key to stock names.

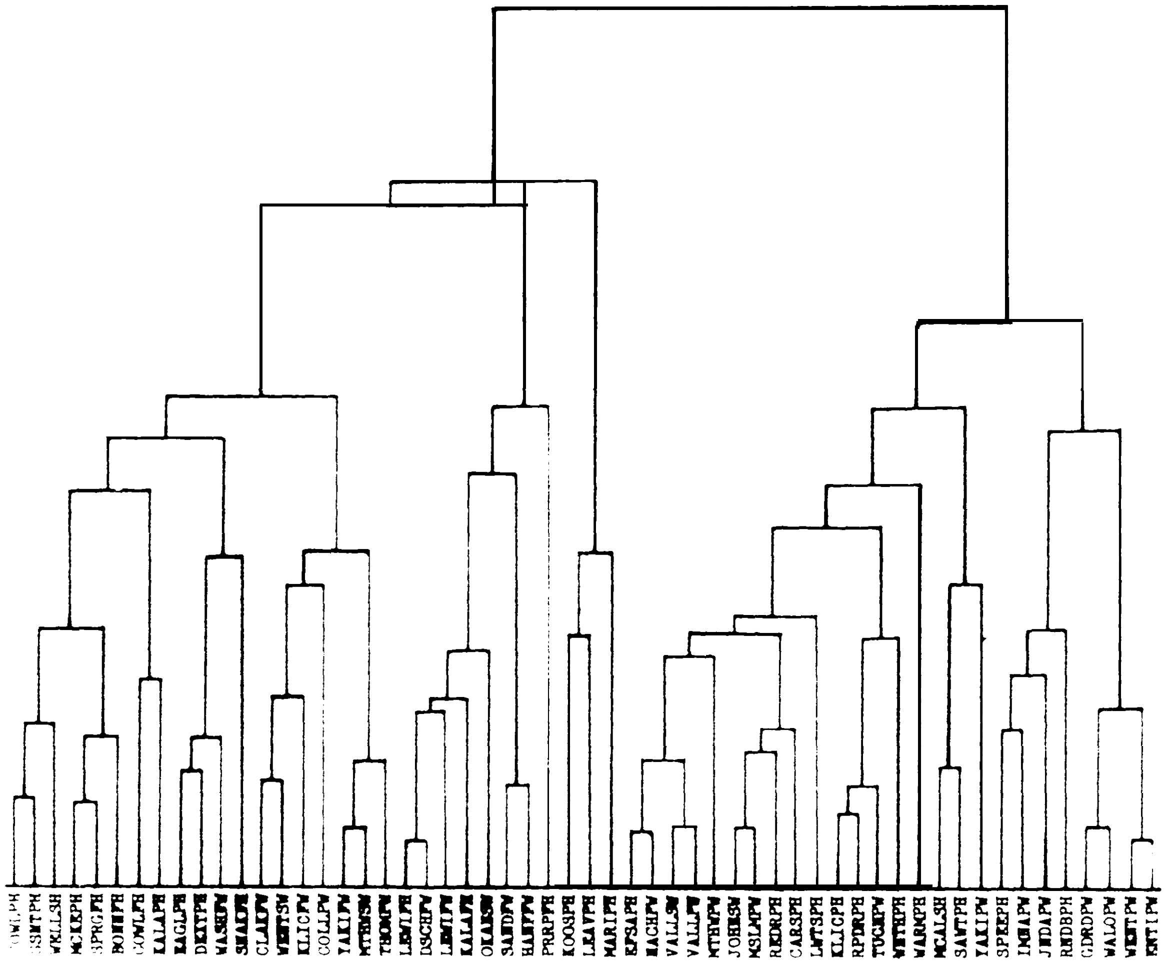

Figure 10. (Chinook salmon cluster analysis using meristic characters. Clustering strategy is correlation. See Table 2 for key to stock names.

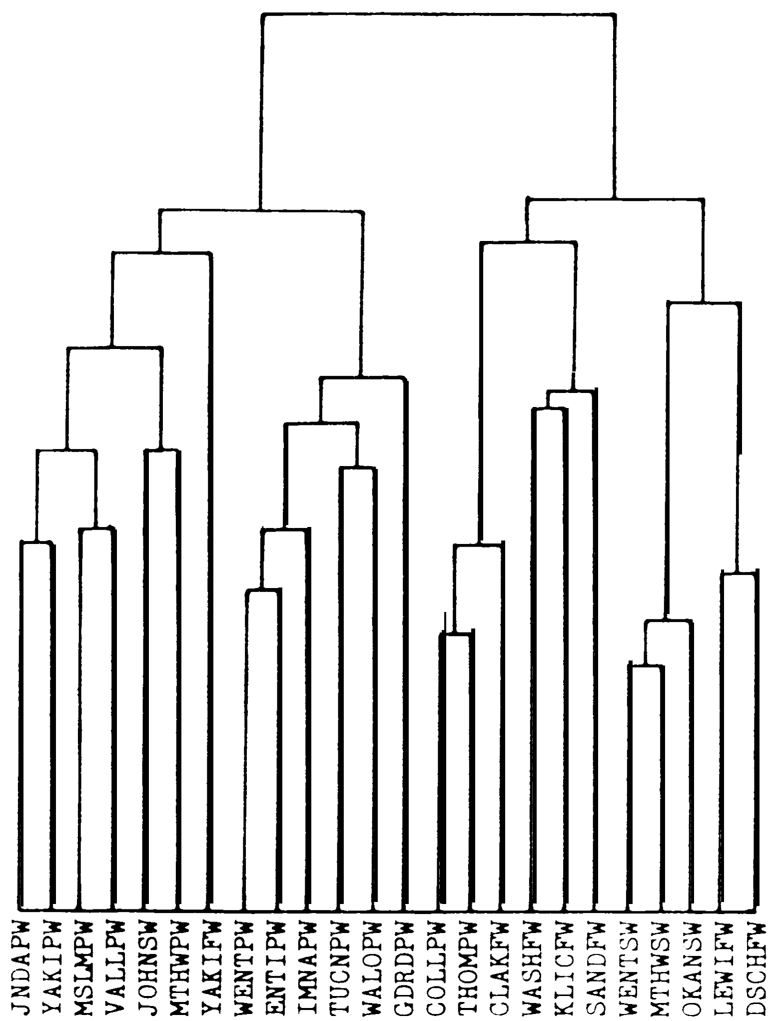

Figure 11. Wild chinook salmon cluster analysis using biochemical, body shape, meristic and life history characters. Clustering strategy is correlation. See Table 2 for key to stock names.

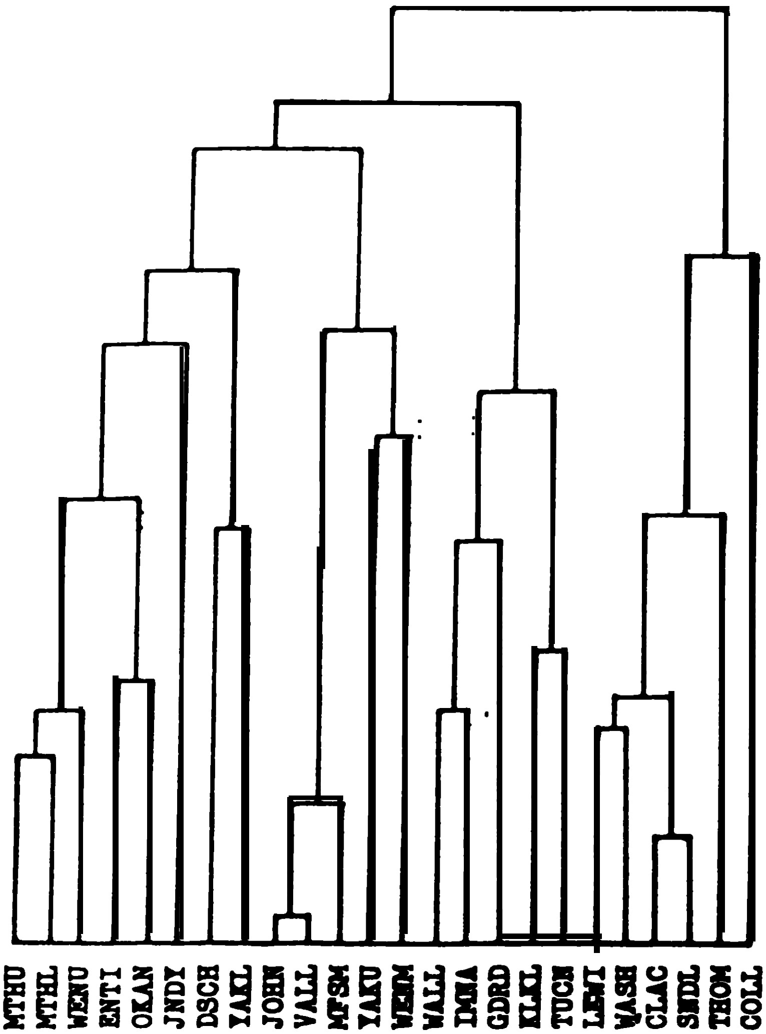

Figure 12. Cluster analysis of spawning streams of chinook salmon based on environmental characters. Chinook stocks found in these streams are from left to right Methow River spring chinook, Methow River summer chinook, Wenatchee River spring chinook, Entiat River spring chinook, Okanagan River summer chinook, John Day River spring chinook, Deschutes River fall chinook, Yakima River fall chinook, Johnson Creek summer chinook, Valley Creek spring chinook, Middle Fork of the Salmon River spring chinook, Yakima River spring chinook, Wenatchee River summer chinook, Wallowa and Lostine River spring chinook, Imnaha River spring chinook, Grande Ronde River spring chinook, Klickitat River fall chinook, Tucannon River spring chinook, Lewis River fall chinook, Washougal River fall chinook, Clackames River fall chinook, Sandy River fall chinook, Thomas Creek spring chinook, and Clackamas River spring chinook.

illustrate groups of similar stocks or streams that are neighbors.

B. Between Years Comparisons

Meristic Characters

Meristic characters are useful for classification because there are differences among the stocks for each meristic character despite temporal variation. Numbers of scales in the lateral series, anal fin rays and pelvic fin rays are stable and did not vary between year classes of chinook (Table 5). The following meristic characters of six stocks of chinook were found to be variable between year classes: Pectoral fin rays, scales above the lateral line, and gill raker counts were different between year classes in three of the six chinook stocks tested. Yearly differences were evident in vertebral counts between year classes in two chinook stocks and dorsal fin rays and branchiostegal rays in one stock.

Chinook stocks appear to have more variability between year classes than steelhead stocks as judged from data on six chinook stocks and nine steelhead stocks. Significant differences for meristic characters were apparent in 24% of the between year comparisons as judged by t-tests in chinook whereas 11% of the t-tests were significant in steelhead.

The number of significant differences in meristic characters between year classes appears to be similar between the chinook stocks that smolt as yearlings and those that smolt as subyearlings and between hatchery and wild chinook stocks. Despite the yearly variation there are still differences among chinook stocks for each of the meristic characters. Analysis of variance tests were still significant

Table 5. Significant differences between year classes of chinook salmon for meristic characters. An "*" indicates a statistically significant difference (p 5 0.5). Blank spaces do not indicate missing data but rather indicate lack of significant differences.

CHINOOK STOCK	FORM	SCALES IN LATERAL SERIES	SCALES ABOVE LATERAL LINE	ANAL RAYS	DORSAL RAYS	PELVIC RAYS
COWLITZ HATCHERY	F		*			
LEWIS HATCHERY	F				*	
CARSON HATCHERY	SP		+			
JOHN DAY RIVER	SP					
GRANDE RONDE RIVER	SP		+			
WELLS DAM HATCHERY	SU					

CHINOOK STOCK	FORM	PECTORAL RAYS	GILL RAKERS	LEFT BRANCHIOSTEGALS	VERTEBRAE
COWLITZ HATCHERY	F				
LEWIS HATCHERY	F.		*		*
CARSON HATCHERY	SP			*	
JOHN DAY RIVER	SP	+	*		*
GRANDE RONDE RIVER	SP	*	+		
WELLS DAM HATCHERY	SU	*			

when the year classes of each of the six stocks were combined thus including the temporal variation with the among stock variation.

Body Shape Characters (Morphology)

Characters associated with body shape can be used to characterize the stocks because there are differences among the stocks for each character despite temporal or between year variation. Differences among chinook stocks were detected for each of the body shape characters when the year classes were combined for each of the seven chinook stocks. These results signify that the within stock variation is only part of the total variation and that there are significant differences among the stocks. All of the characters were significantly different between years in at least two of the seven chinook stocks tested (Table 6). The snout to operculum length was the most variable being significantly different between years in six of seven chinook stocks tested. The most stable characters were head depth, adipose to upper caudal fin and caudal peduncle depth which were different between year classes for two of the seven chinook stocks. There may be slightly more variation between year classes for wild chinook stocks in comparison to hatchery chinook stocks.

Chinook salmon stocks appear to have higher variability between year classes than steelhead trout as judged from data on seven chinook stocks and eight steelhead stocks. Fifty-four percent of the between year comparisons of body shape characters of chinook salmon were significantly different between year classes whereas only 20% of the

Table 6. Significant differences between year classes of chinook salmon for morphometric characters. An "*" indicates a statistically significant difference (p <_ 0.5). Blank spaces do not indicate missing data but rather indicate lack of significant differences. Numbers in parentheses are landmark points (see Figure ??).

CHINOOK STOCK	FORM	SNOUT TO TOP OF HEAD (1x2)	SNOUT TO OPERCULA (1x16)	MAXILLARY LENGTH (1x17)	HEAD DEPTH-1 (2x14)	HEAD DEPTH-2 (2x15)	CAUD.PED LENGTH (4x7)
CARSON HATCHERY	SP						*
WELLS HATCHERY	SU		*		*		
JOHN DAY RIVER WILD	SP	*	*	*	*	*	
GRAND RONDE WILD	SP		*	*	*		
COWLITZ HATCHERY	F		*	*			
OKANAGAN RIVER WILD	SU	*	*		*		
KLICKITAT HATCHERY	SP	*	*		*	*	

CHINOOK STOCK	FORM	CAUD.PED DEPTH-1 (4x9)	CAUD.PED DEPTH-2 (6x8)	CAUD.PED DEPTH-3 (6x9)	ANAL BASE (9x10)	HEAD WIDTH	INTER-ORBITAL WIDTH
CARSON HATCHERY	SP		*	*	*	*	*
WELLS HATCHERY	SU					*	*
JOHN DAY RIVER WILD	SP	*			*	*	*
GRAND RONDE WILD	SP		*		*	*	*
COWLITZ HATCHERY	F			*	*		
OKANAGAN RIVER WILD	SU	*	*		*		
KLICKITAT HATCHERY	SP		*			*	*

between year comparisons of steelhead trout body shape were significantly different.

Significant differences between year classes were found in stocks of wild chinook salmon for 64% of the comparisons of body shape characters while hatchery chinook stocks had significant differences in 46% of the comparisons of characters associated with body shape. More between year variation in body shape was detected in spring chinook stocks then in summer or fall chinook stocks. Spring chinook stocks had significant differences between year classes for 65% of the comparisons of body shape characters while the body shape characters of the fall and summer chinook had significant differences between year classes for 39% of the comparisons.

Electrophoretic Characters

Electrophoretic characters are useful for classification purposes despite variation between year classes. Enzyme gene frequencies were different in 30% of the comparisons between year classes of 13 stocks (Table 7) however between year variation was small compared to differences among stocks. Isocitrate dehydrogenase was the most variable enzyme system with differences between the year classes in eight of the 14 stocks tested (Table 7). Superoxide dismutase was the most stable with differences apparent between year classes in only one out of 13 stocks tested.

Between year variation in electrophoretic characters is higher for hatchery stocks (38%) than for wild stocks (22%). Spring chinook have the highest between years variation among the forms with 35% of the

Table 7. Between year variability for enzyme gene frequencies of chinook salmon as judged by chi-square tests.

CHINOOK STOCKS	Enzyme systems with statistically significant differences in gene frequencies	Enzyme systems with similar gene frequencies
EAGLE CREEK HATCHERY SPRINGS, 83 vs. 85	MPI, IDDH	AH, TAPEP, SOD, PGK, MDH-34
LITTLE WHITE SALMON HATCH. SPRINGS, 83 vs. 85	GPI-2, TPEP	MDH-34, MPI, PGK SOD
MCKENZIE HATCHERY SPRINGS, 83 vs. 85	IDDH	AH, MDH-34, MPI SOD, PGK
CARSON HATCHERY SPRINGS, 83 vs. 85	IDDH, PGK	MPI, TAPEP, SOD
ROUND BUTTE HATCHERY SPRINGS, 83 vs. 85	IDDH, PGK	SOD
LEAVENWORTH HATCHERY SPRINGS, 83 vs. 85	TAPEP, PGK, SOD	MDH-34, MPI
SANDY RIVER WILD FALLS, 83 vs. 85		AH, IDDH, MPI, MPI, TAPEP
JOHN DAY RIVER WILD SPRINGS, 84 vs. 85	IDDH, MDH-34, PGK	MPI, SOD, TAPEP
DESCHUTES RIVER WILD FALLS, 83 vs. 85		AH, ADH, IDDH, MDH-34, MPI, DPEP, SOD

Table 7. (Continued).

CHINOOK STOCKS	Enzyme systems with statistically significant differences in gene frequencies	Enzyme systems with similar gene frequencies
HANFORD REACH WILD FALLS, 83 vs. 85	IDDH, MPI	MDH-34, TAPEP, PGK
WENATCHEE RIVER WILD SPRINGS, 83 vs. 85	MPI	IDDH, MDH-34
WALLOWA-LOSTINE R. WILD SPRINGS, 83 vs. 84		SOD, MPI, IDDH
METHOW RIVER WILD SPRINGS, 83 vs. 84	MPI, TAPEP, IDDH	SOD, MDH-34
OKANOGAN RIVER WILD SUMMERS, 83 vs. 85		IDDH, LDH-5, MDH-34, MPI, TAPEP, PGK, AH
TUCANNON RIVER WILD SPRINGS, 84 vs. 85	GPI-2	IDDH, MPI, SOD
GRANDE RONDE R. WILD SPRINGS, 83 vs. 84		SOD, MPI, IDDH
IMNAHA RIVER WILD SPRINGS, 83 vs. 84	PGK-2	SOD, IDDH, MDH-34

tests being significant compared to 20% for spring chinook and 13% for fall chinook.

C. Incubation Temperature and Meristic Characters

The differences in meristic counts among the hatchery stocks of chinook are not explain by the water temperature during the first month of incubation. None of the regression slopes of incubation temperature on meristics characters were significantly different from zero. The correlation coefficients ranged from -.36 for anal fin rays to .12 for pectoral fin rays (Table 8). Several studies have shown that incubation temperature does affect counts of meristic characters (Taning, 1952; Seymour, 1959). Apparently, the differences among stocks in countable characters has a strong genetic basis and is greater than the variation caused by the relationship between the meristic characters and incubation temperature.

D. Validation of Body Shape Characters

Truss type measurements in the caudal peduncle region of chinook salmon are useful for our analysis because these measurements are not affected by condition factor (Figures 13 and 14). Characters associated with the head region and some of the classical body measurements may also be useful although the results were not as consistant between size groups as were the truss type measures in the caudal peduncle region (Figures 13 and 14).

Table 8. Correlation coefficients and significance levels for testing the probability that b = 0 associated with the regression of meristic characters and incubation temperature for chinook salmon and steelhead trout.

	CHINOOK		STEELHEAD	
MERISTIC CHARACTER	CORRELATION COEFFICIENT	ALPHA LEVEL	CORRELATION COEFFICIENT	ALPHA LEVEL
SCALES IN LATERAL SERIES	0.019	0.927	0.655	0.003
SCALE ABOVE LATERAL LINE	0.078	0.704	0.508	0.031
ANAL FIN RAYS	-0.362	0.069	0.002	0.995
DORSAL FIN RAYS	-0.115	0.578	-0.115	0.649
PELVIC FIN RAYS	-0.042	0.840	-0.482	0.043
PECTORAL FIN RAYS	0.120	0.558	0.137	0.588
GILL RAKERS	-0.311	0.122	0.160	0.525
BRANCHIOSTEGAL RAYS	-0.279	0.167	-0.499	0.035
VERTEBRAE	0.001	0.995	-0.249	0.320

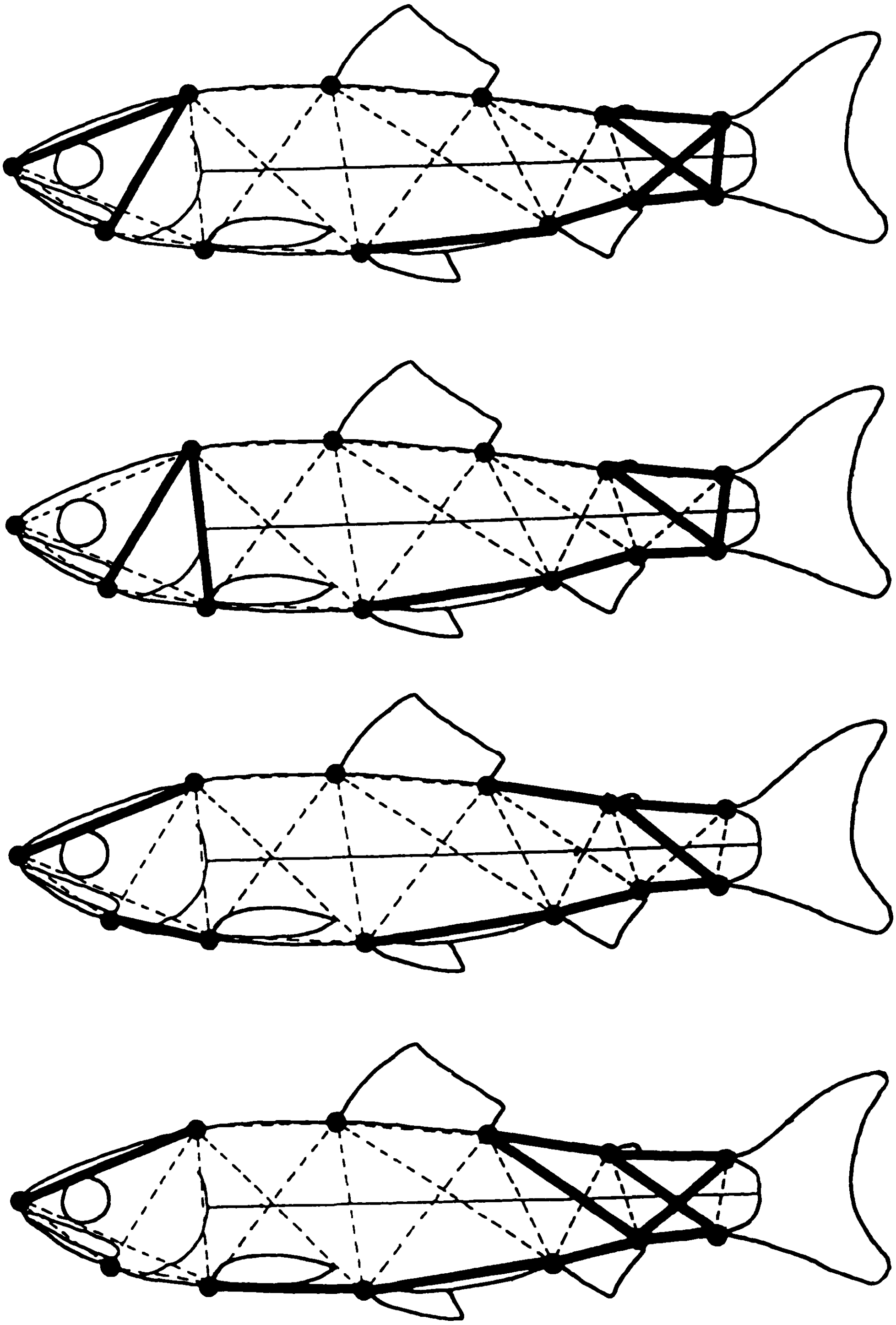

Figure 13. Solid lines indicate truss-type measurements that do not differ ($p < .95$) between chinook salmon with high and low condition factors. The size groups range From fingerlings (top) to smolts (bottom). Dotted line indicate characters which had statistically significant differences between chinook salmon with high and low condition factors.

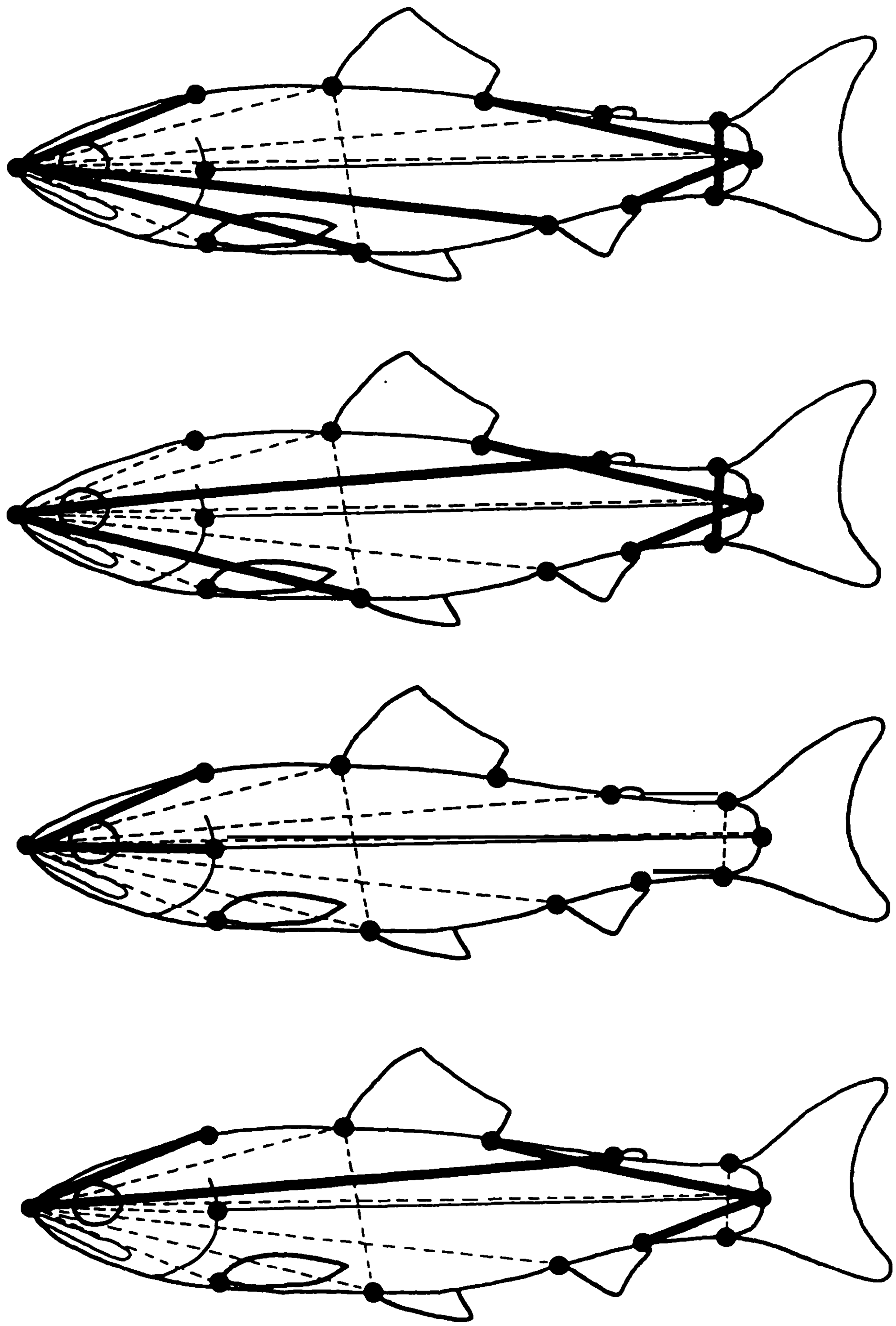

Figure 14. Solid lines indicate classical measurements that do not differ ($p < .95$) between chinook salmon with high and low condition factors. The size groups range from fingerlings (top) to smolts (bottom). Dotted lines indicate characters which had statistically significant differences between chinook salmon with high and low condition factors.

Truss type measures in the abdominal region are greatly affected by condition factor in chinook salmon and should not be used in the comparison among stocks. Based on these results, we included only those morphometric characters in the head and caudal peduncle region that are independent of condition factor for our final analysis.

E. Discrimination Power of Stock Characteristics

All of the meristic and body shape characters have useful information for discriminating among the stocks. Significant differences (p = 0.99) for each body shape and meristic character exist among the 56 hatchery and wild chinook stocks from three brood years. These results indicate that there are differences among the stocks for each body shape or meristic character after correlations with other aspects of body shape or other meristic characters are taken into account as evaluated by analysis of covariance.

Several of the stock characters are associated with certain habitat types (Table 9). In general, chinook stocks that spawn in small streams tend to have larger fins and wider heads than chinook stocks that spawn in larger stream basins. Furthermore, spring chinook stocks east of the Cascades, when compared to fall chinook and spring chinook from west of the Cascades, generally have more vertebrae (Figure 15), higher frequencies of the slow variant allele for phosphoglycerate kinase (Figure 16) and higher frequencies of the common alleles for mannose phosphate isomerase and aconitate hydratase (Figures 17 and 18). The fin sizes and head width are all inversely correlated with basin area which actually reflects location of spawning

Table 9. Correlation coefficients between the characteristics of wild chinook salmon and the environmental characteristics of their respective stream systems. Only correlation coefficients greater than or less than + 0.6 are listed.

STOCK CHARACTERS	ENVIRONMENTAL CHARACTERS	CORRELATION
PHOSPHOGLYCERATE KINASE	SLOPE OF MIGRATION AREA	-0.698
	MIGRATION ROUTE LOCAL RELIEF	-0.741
	DISTANCE TO COL. MOUTH	-3.694
	MINIMUM AIR TEMPERATURE	0.692
MANNOSE-6-PHOSPHATE ISOMERASE	MIGRATION ROUTE LOCAL RELIEF	0.656
	ANNUAL PRECIPITATION	-0.747
	ANNUAL RUNOFF	-0.770
	DISTANCE TO COL. MOUTH	0.732
	MINIMUM AIR TEMPERATURE	-0.784
SCALES IN LATERAL SERIES	PEAK ENTRANCE COL. MOUTH	0.627
	PEAK SPAWNING DATE	0.609
	SPAWNING ELEVATION	0.639
	DISTANCE TO COL. MOUTH	0.631
	MINIMUM AIR TEMPERATURE	-0.627
VERTEBRAE	SPAWNING ELEVATION	0.704
	DISTANCE TO COL. MOUTH	0.754
	ANNUAL FROST-FREE DAYS	-0.611
	MINIMUM AIR TEMPERATURE	-0.745
PECTORAL FINS	BASIN SIZE	-0.651
ANAL FIN HEIGHT	SPAWNING ELEVATION	0.641
	BASIN SIZE	-0.672
CAUDAL FIN (8 X 21)	BASIN SIZE	-0.642
HEAD WIDTH	BASIN SIZE	-13.674

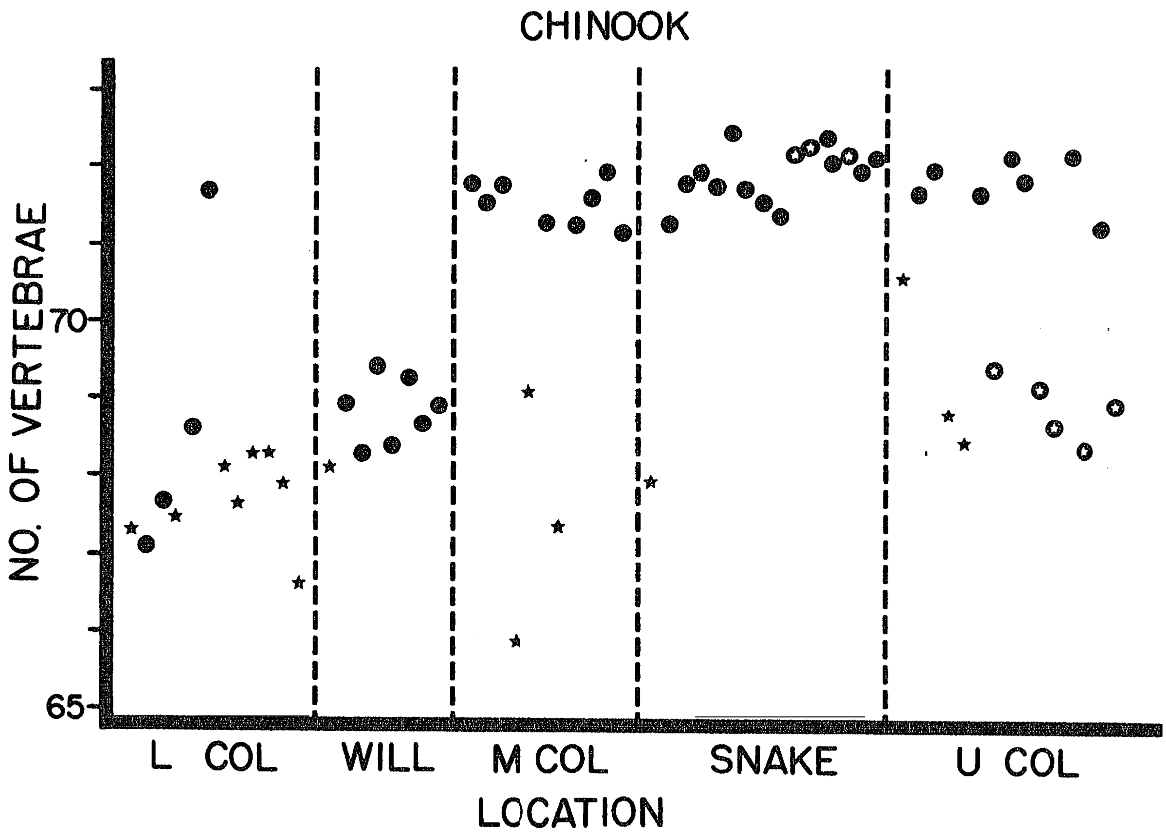

Figure 15. Number of vertebrae vs. geographical zone in spring (dots), summer (circled stars) and fall (stars) chinook stocks. Stocks and geographical zones are in order from lower to upper Columbia but distances within and between geographical zones are not to scale.

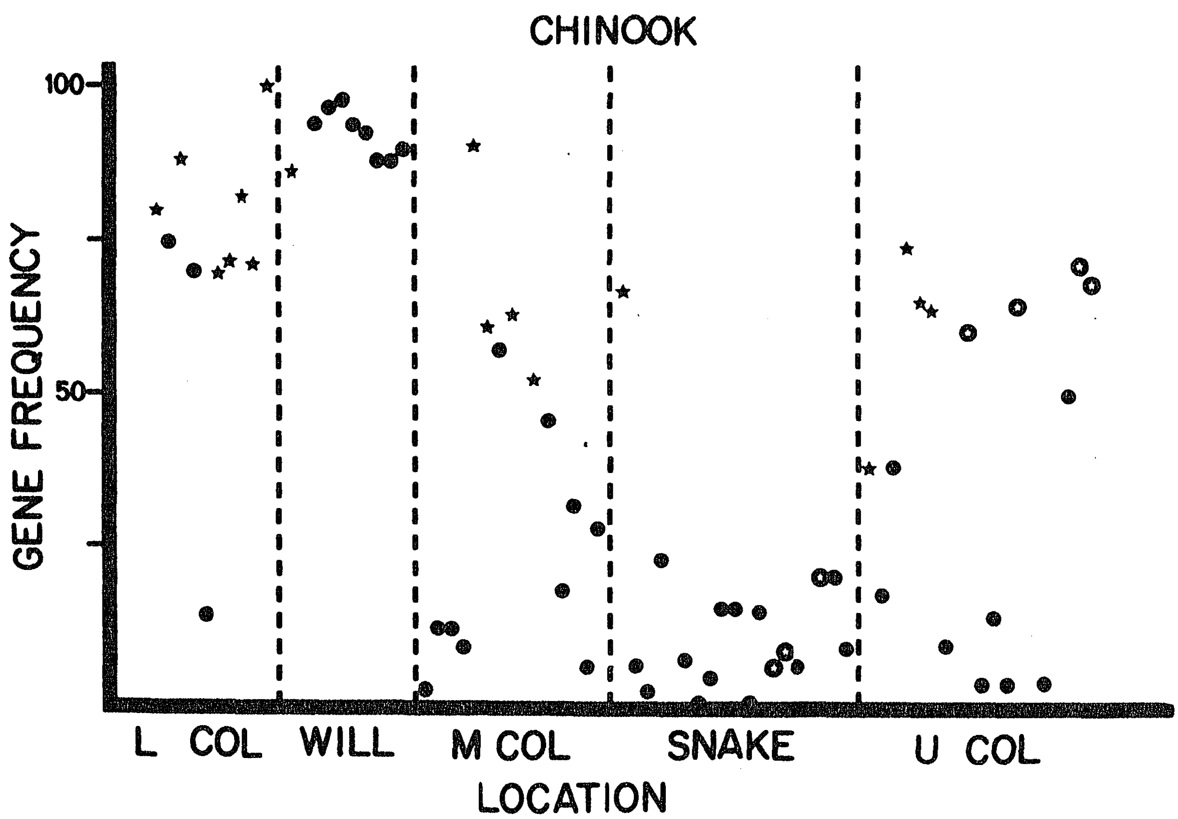

Figure 16. Frequency of common allele of phosphoglycerate kinase vs. geographical zone in spring (dots), summer (circled stars) and fall (stars) chinook stocks. Stocks and geographical zones are in order from lower to upper Columbia but distances within and between geographical zones are not to scale.

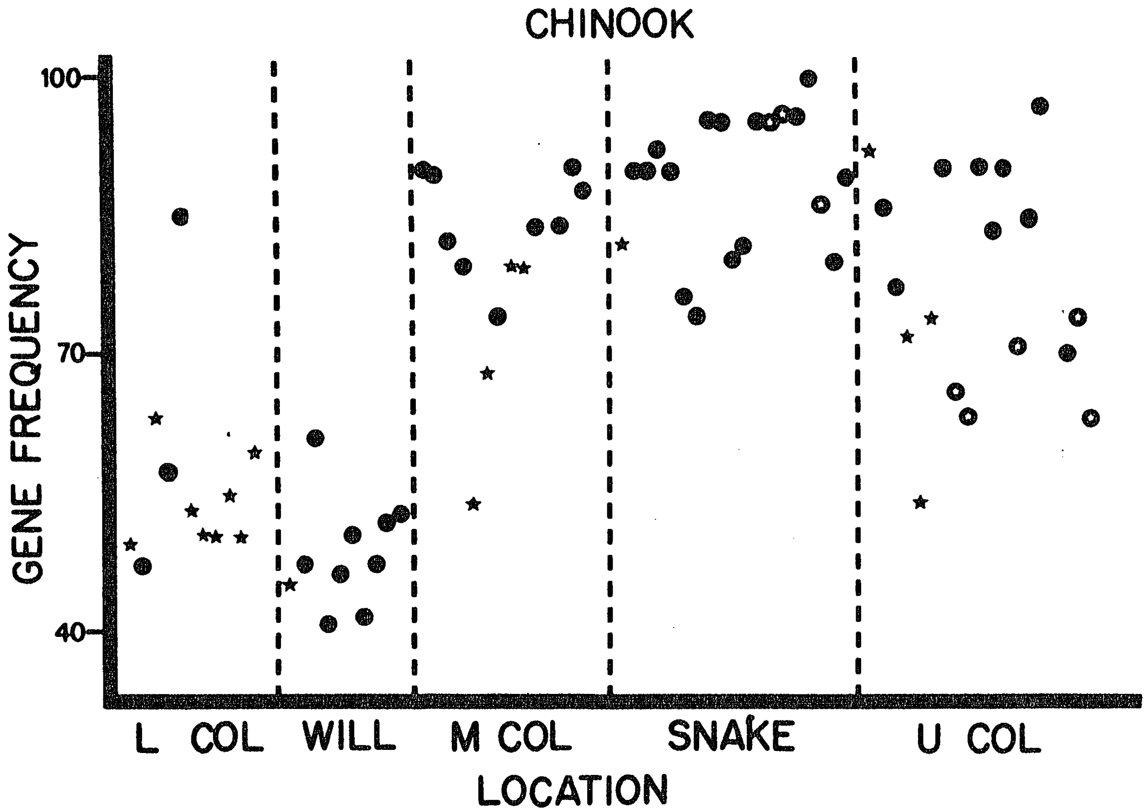

Figure 17. Frequency of common allele of mannose phosphate isomerase vs. geographical zone in spring (dots), summer (circled stars) and fall (stars) chinook stocks. Stocks and geographical zones are in order from lower to upper Columbia but distances within and between geographical zones are not to scale.

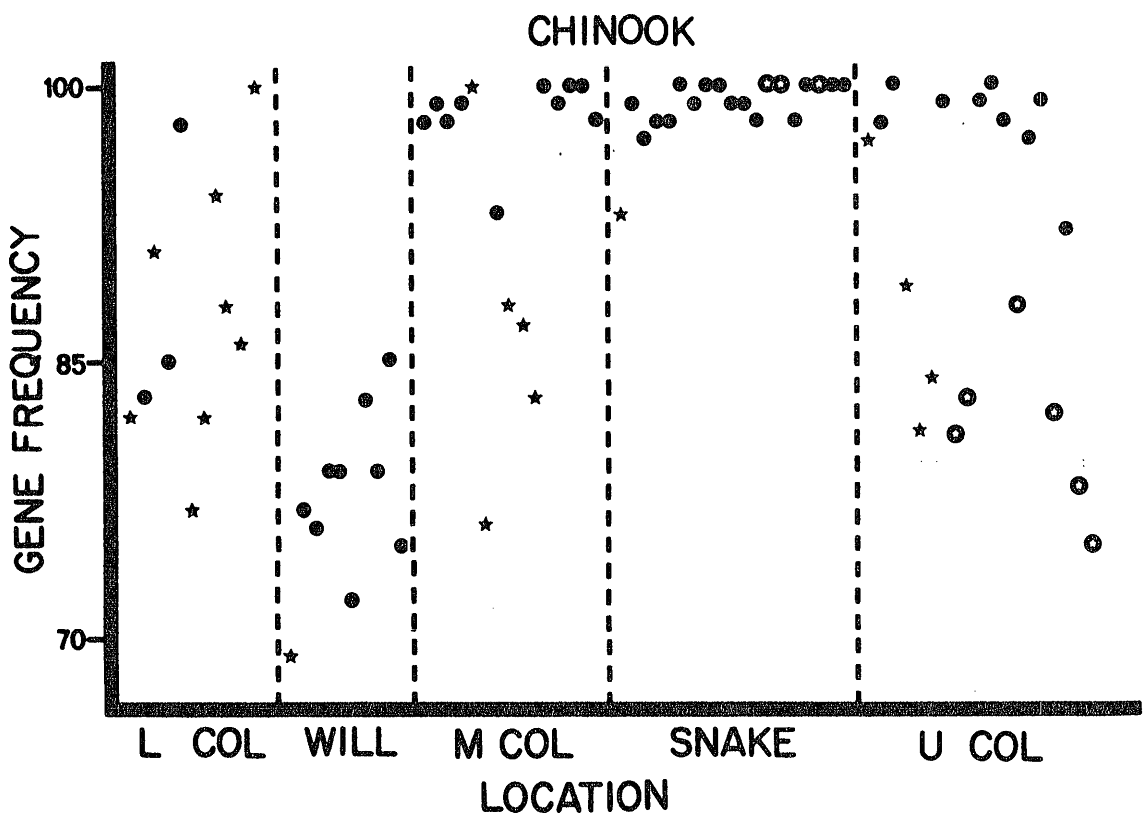

Figure 18. Frequency of common allele of aconitate hydratase vs. geographical zone in spring (dots), summer (circled stars) and fall (stars) chinook stocks. Stocks and geographical zones are in order from lower to upper Columbia but distances within and between geographical zones are not to scale.

areas. Chinook stocks that smolt as yearlings (spring chinook and summer chinook from the Salmon River, Idaho) tend to spawn in the upper reaches of stream systems and thus have smaller basin areas than chinook stocks that smolt as sub-yearlings (fall chinook and summer chinook from the upper Columbia River) which tend to spawn in the mainstems of the Columbia and its tributaries.

Meristic counts and enzyme gene frequencies are correlated with stream characters that reflect the division between streams east and west of the Cascades. Streams east of the Cascades 1) are further from the mouth of the Columbia (distance), 2) have a drier and colder climate (precipitation, number of frost-free days and minimum annual temperature), 3) are higher in elevation and 4) have a lower runoff.

Chinook stocks inhabiting stream systems with a native natural vegetation type of western hemlock had the four highest values for the common allele of phosphoglycerate kinase and the six lowest values of the common allele of mannose-6-phosphate isomerase. These streams were all located west of the Cascade Mountains. Chinook with the four highest values of the common phosphoglycerate kinase allele were also located in streams flowing through ultisol-type soil (Highsmith, 1973). Even though there were several other instances where relationships between the presence-absence type stream characters and the characters of wild stocks had values of the correlation coefficient, greater than 9.6, most of these appear to be the result of chance. Because there are just two states for these stream characters, high correlation coefficients could be caused by small differences between the two states or by several unusual values.

F. Heterozygosity

The fall and upper Columbia summer chinook stocks in cluster 6 of Figure 7 had the highest average relative heterozygosity in a comparison among the seven clusters of chinook stocks. The average heterozygosity values ranged from .1277 for the stocks in cluster 6 to

spring and summer chinook from Idaho. Fall chinook stocks had the highest relative heterozygosity in the comparisons among the forms of chinook with an average value of .1185 followed by the summer chinook stocks at .0983 and the spring chinook stocks with an average heterozygosity of .0772. There were no significant differences in average relative heterozygosity between hatchery and wild chinook stocks.

II. STEELHEAD

A. Stock Classification

Columbia River steelhead stocks consist of two main groups which are located east and west of the Cascade mountains (Figure 19). These two qroups are each comprised of three subgroups or clusters of stocks. One of the subgroups from east of the Cascade Mountains is comprised of wild summer steelhead from a wide geographical area including tributaries of the Columbia River between Fifteenmile Creek and the Entiat River, the lower Snake River and the Salmon River (Cluster 1 of

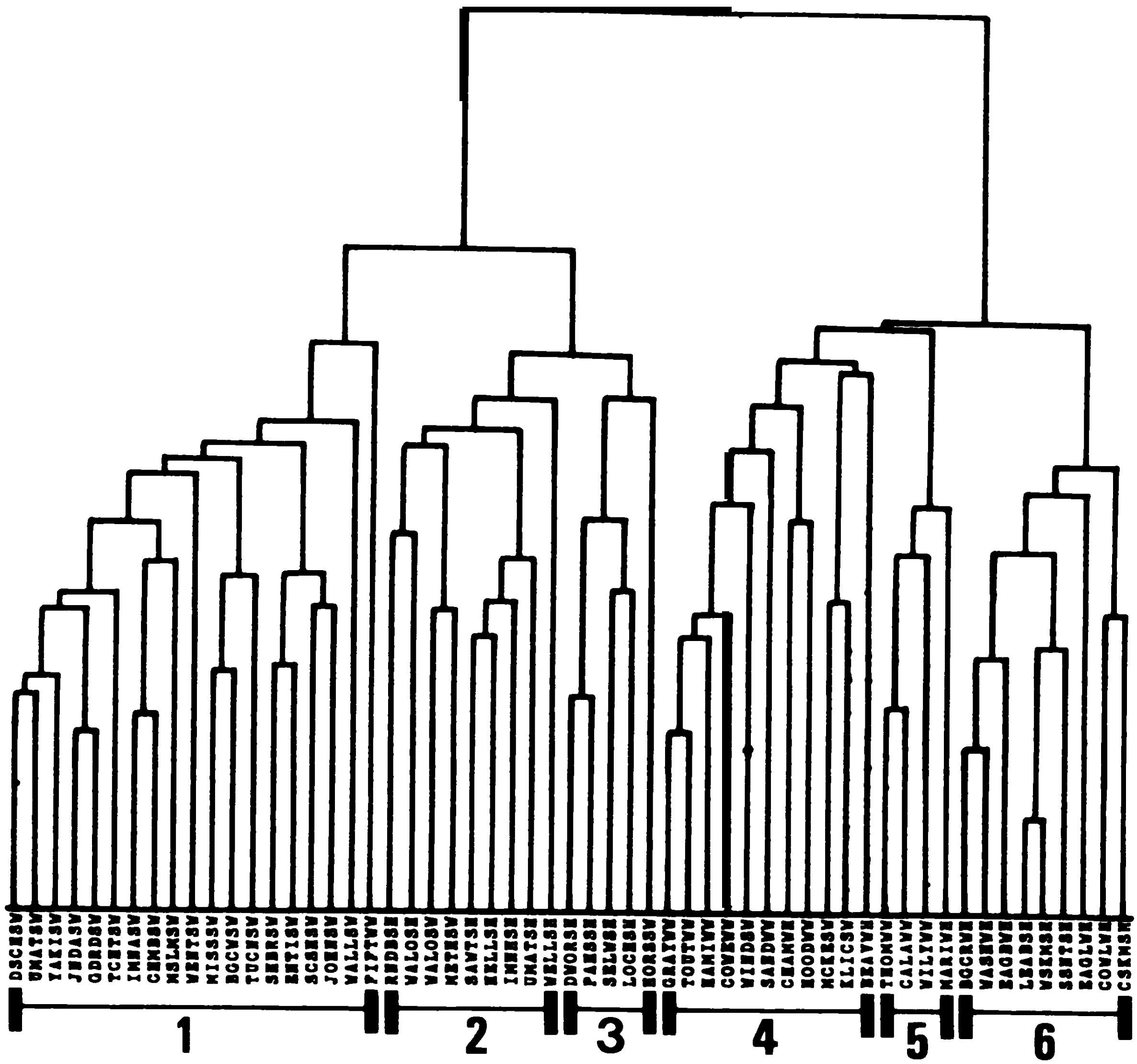

Figure 19. Steelhead trout cluster analysis using biochemical, body shape, meristic and life history characters. Clustering strategy is correlation. See Table 3 for key to stock names.

Figure 19). The stocks in this group are distinguished by the greatest head length, maxillary length, head depth, and interorbital width, and the lowest average caudal peduncle length.

Another subgroup from east of the Cascades is primarily composed of hatchery summer steelhead stocks from tributaries of the Columbia and the lower Snake River (Cluster 2 of Figure 19). This group Is characterized by the earliest time of entry into fresh water, the highest average gene frequencies of glycerol-3-phosphate dehydrogenase, and the lowest average head depth.

The third subgroup (Cluster 3 of Figure 19) of eastern steelhead has both hatchery and wild stocks from the Clearwater and Salmon Rivers in Idaho. This group is characterized by the lowest average value for head width, interorbital width, aconitate hydratase gene frequency, lactate dehydrogenase-4 gene frequency, and dipeptidase gene frequency and the highest average values for scales in the lateral series, malate dehydrogenase gene frequency, and superoxide dismutase gene frequency.

The second main group includes all of the stocks west of the Cascade Mountains (Clusters 4-6 of Figure 19). One of the subgroups (Cluster 4) is composed of seven wild winter steelhead stocks, two wild summer steelhead stocks and two hatchery winter steelhead stocks. This group has the following characteristics: greatest head width, highest number of anal fin rays and branchiostegal rays and the lowest average gene frequencies of malate dehydrogenase (NADP+) and glucose phosphate isomerase.

Another subgroup in Figure 19 (Cluster 5) has four winter steelhead stocks from the Willamette River drainage. These stocks have the latest average time of entry into freshwater and time of spawning, the highest average values for aconitate hydratase gene frequency and glucose phosphate isomerase-3 gene frequency and the lowest average number of anal fin rays and gene frequencies of glycerol-j-phosphate dehydrogenase and superoxide dismutase.

The final subgroup of similar stocks is comprised of summer and winter hatchery steelhead from west of the Cascades (Cluster 6 of Figure 13). The summer steelhead stocks in this group are all originally from the Skamania Hatchery stock of summer steelhead. This group has the earliest average spawning time, the lowest average head and maxillary length, lowest number of scales in the lateral series and above the lateral line, and the lowest gene frequency of malate dehydrogenase. In addition, this group has the highest average values for caudal peduncle length, L-lactate dehydrogenase gene frequency and dipeptidase gene frequency.

The general conclusions that we would draw from the divisive cluster analysis and the canonical variate analysis are the same as the conclusions drawn from the agglomerative cluster analysis. The divisive analysis separated stocks from east and west of the Cascade Fountains and between hatchery and wild stocks. According to the canonical variate analysis, the main separation was between stocks from east and west of the Cascade Mountains.

Hatchery steelhead stocks had smaller head dimensions, larger body dimensions in the caudal peduncle region and fewer branchiostegal rays than the wild steelhead stocks (Table 10). The head and body characters and branchiostegal rays are the only characters that are

Table 10. Mean values of specific characters with significant differences between groups of winter and summer or hatchery and wild steelhead trout. Estimated freshwater entry and peak spawning dates were averaged for each group. References to seasons denote the particular season of adult return.

STEELHEAD COMPARISONS	CHARACTERS	WINTERS	SUMMERS
HATCHERY WINTERS VS. HATCHERY SUMMERS	DATE OF FRESHWATER ENTRY	JANUARY 5	AUGUST 20
	ANAL FIN BASE (9X10)	9.33	8.71
	SCALES IN LATERAL SERIES	128.67	142.11
	ROWS ABOVE LATERAL LINE	24.83	27.84
	L-LACTATE DEHYDROGENASE	0.85	0.52
	MALATE DEHYDROGENASE (NADP+)	0.87	0.97
	SUPEROXIDE DISMUTASE	0.61	0.88
WILD WINTERS VS. WILD SUMMERS	DATE OF FRESHWATER ENTRY	MARCH 1	JULY 27
	CAUDAL PEDUNCLE LENGTH (4X7)	37.15	36.30
	PECTORAL FIN LENGTH	16.22	16.50
	DORSAL FIN LENGTH	12.02	12.88
	ANAL FIN LENGTH	10.47	10.96
	SCALES IN LATERAL SERIES	133.47	149.85
	ROWS ABOVE LATERAL LINE	26.87	30.90
	DORSAL RAYS	11.55	1l.72
	PECTORAL RAYS	14.38	14.07
	BRANCHIOSTEGAL RAYS	11.88	11.53
	ACONITATE HYDRATASE	0.90	3.76
	GLYCEROL-3-PHOSPHATE DEHYDROGENASE	0.92	0.99
	L-LACTATE DEHDROGENASE	0.76	0.35
	MALATE DEHYDROGENASE	0.91	0.98
	MALATE DEHYDROGENASE (NADP+)	0.86	1.00
	DIPEPTIDASE	0.98	0.91
	SUPEROXIDE DISMUTASE	0.66	0.91

Table 10. (Continued).

STEELHEAD COMPARISONS	CHARACTERS	HATCHERY	WILD
EAST HATCHERY SUMMERS VS. EAST WILD SUMMERS	HEAD LENGTH (1X2)	17.37	18.62
	HEAD LENGTH (1x16)	21.88	23.99
	HEAD DEPTH (2X14)	15.49	15.85
	HEAD DEPTH (2X15)	16.98	17.38
	HEAD WIDTH	9.33	10.00
	MAXILLARY LENGTH	10.00	11.22
	CAUDAL PEDUNCLE LENGTH 1	37.15	36.30
	CAUDAL PEDUNCLE LENGTH 2	23.44	22.91
	CAUDAL PEDUNCLE DEPTH 1	9.12	9.33
	ANAL FIN BASE	8.91	9.33
	INTERORBITAL WIDTH	5.76	6.17
	ROWS ABOVE LATERAL LINE	29.90	31.02
	DORSAL RAYS	11.55	11.72
	BRANCHIOSTEGAL RAYS	11.31	11.56
	ISOCITRATE DEHYDROGENASE	0.67	0.64
WEST HATCHERY STOCK VS. WEST WILD WINTERS	PEAK SPAWNING DATE	JANUARY 25	MARCH 25
	HEAD LENGTH (1X2)	17.38	18.62
	HEAD LENGTH (1X16)	20.89	23.44
	HEAD DEPTH (2X14)	15.14	15.85
	HEAD WIDTH	9.55	10.00
	MAXILLARY LENGTH (1 X17)	9.55	10.00
	CAUDAL PEDUNCLE LENGTH (4X7)	38.02	36.30
	CAUDAL PEDUNCLE LENGTH (4X9)	23.99	22.91
	ANAL FIN BASE (9X10)	8.91	9.33
	ROWS ABOVE LATERAL SERIES	24.84	26.55
	BRANCHIOSTEGAL RAYS	11.51	11.81
	ACONITATE HYDRATASE	0.93	0.86

significantly different in both of the comparisons between hatchery and wild stocks. This is based on the results of t-tests used to make the following comparisons: 1) the wild summer steelhead in cluster 1 with the hatchery summer steelhead stocks in cluster 5, and 2) the wild winter steelhead in cluster 4 with the hatchery winter and summer steelhead in cluster 6.

Wild winter and wild summer steelhead differ from each other in life history, meristic and electrophoretic characters but not in body shape characters (Table 10). Winter steelhead have a later entry into fresh water, lower values for scales in the lateral series, scales above the lateral line, malate dehydrogenase (NADP+) gene frequency and superoxide dismutase gene frequency and higher values of branchiostegal fin rays and L-lactate dehydrogenase gene frequency. This contention is based upon t-tests used to evaluate comparisons of characters between wild winter steelhead from west of the Cascades and wild summer steelhead from east of the Cascades.

The classification of steelhead stocks using either electrophoretic characters (Figure 20) or meristic characters (Figure 21) both suggest that the main differences between steelhead stocks are between those stocks from east and west of the Cascade Mountains. In both of these analyses there was a tendency for geographically close stocks (e.g. stocks in the Willamette River) to be similar.

Hatchery steelhead stocks tend to have different body shapes than wild steelhead stocks. In the cluster analysis based or body share alone (Figure 22) wild stocks generally were grouped together and hatchery stocks were generally grouped together.

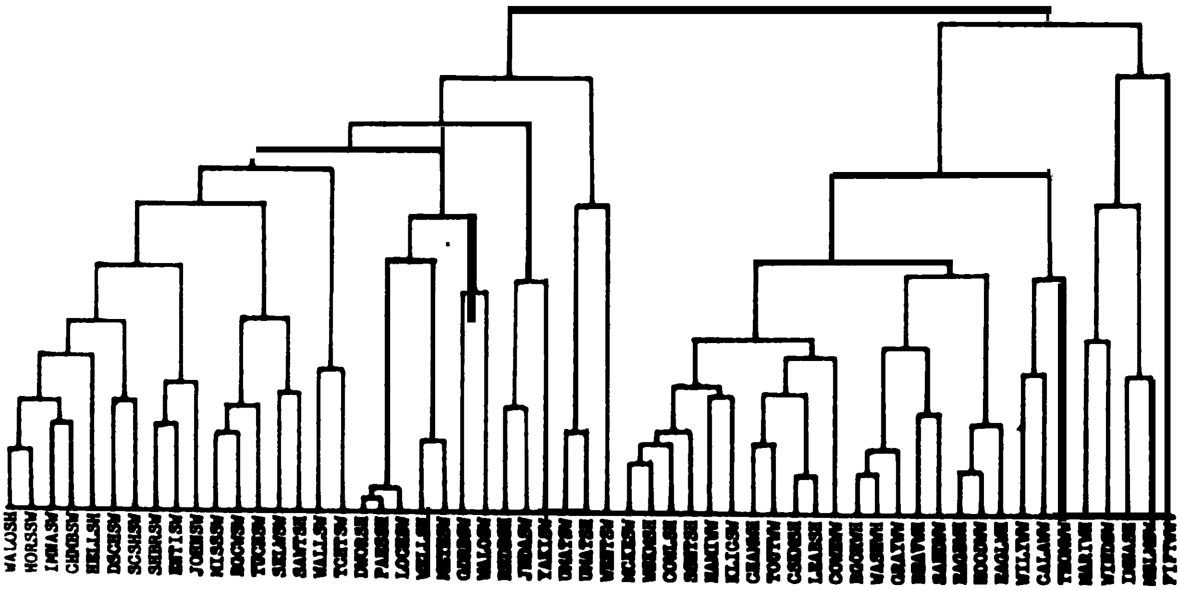

Figure 20. Steelhead trout cluster analysis using biochemical characters. Clustering strategy is correlation. See Table 3 for key to stock names.

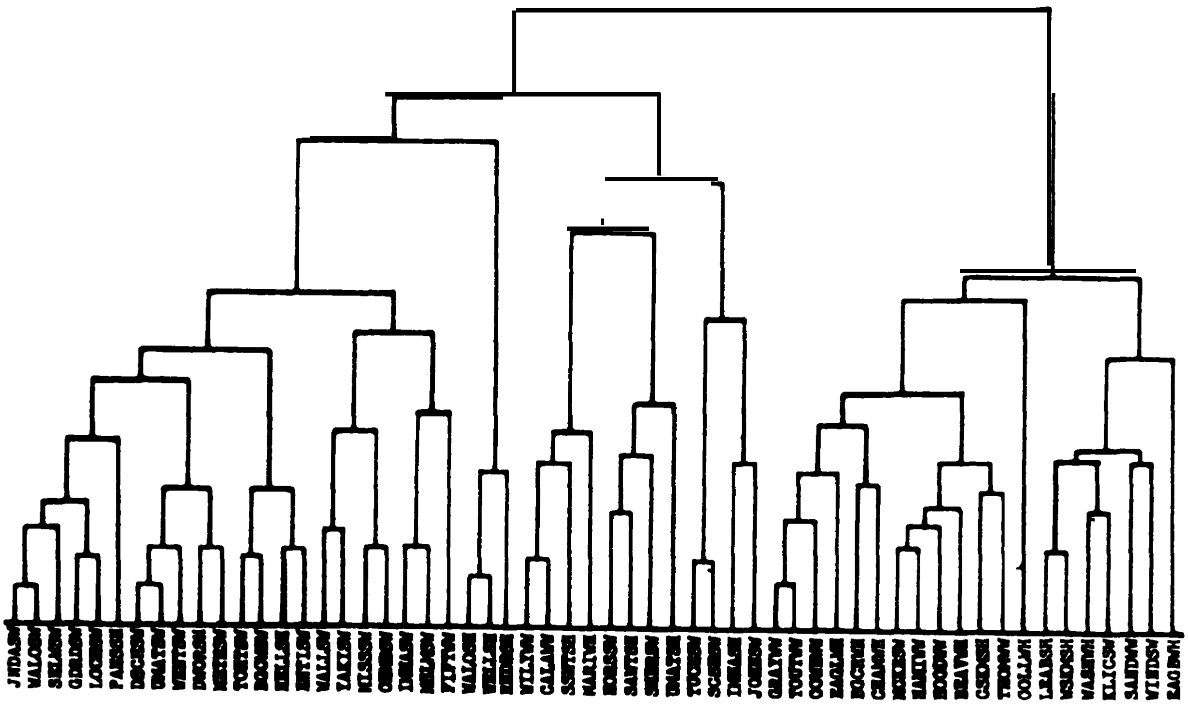

Figure 21. Steelhead trout cluster analysis using meristic characters. Clustering strategy is correlation. See Table 3 for key to stock names.

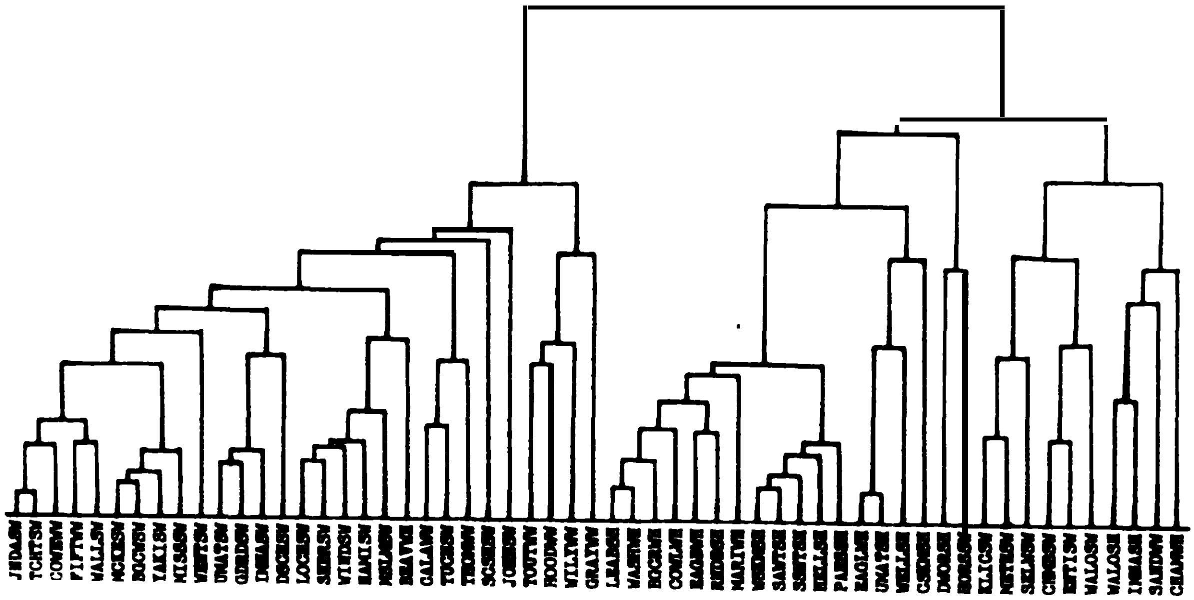

Figure 22. Steelhead trout cluster analysis using body shape characters. Clustering strategy is correlation. See Table 3 for key to stock names.

Wild steelhead stocks originating from phenotypically similar stream systems tend to be alike. The patterns derived from the cluster analyses of wild steelhead stocks (Figure 23) are similiar to the patterns derived from the cluster analysis of the stream systems (Figure 24). The stream systems can be divided into three groups: 1) tributaries of the lower Clearwater, the lower Snake River and the Columbia River between the Hood and Snake rivers; 2) Streams from west of the Cascade Mountains; and 3) tributaries of the upper Columbia River, the upper Clearwater River and the Salmon River. Cluster analysis of the wild steelhead stocks also results in three main groups. Cluster 1 of Figure 23 resembles cluster 1 of Figure 24 except that the Wenatchee and two Salmon River stocks are included. The steelhead stocks of cluster 2 originated from many of the stream systems found in cluster 3 of Figure 24 as well as three stocks form the lower Snake River. Cluster 3 of Figure 23 and cluster 2 of Figure 24 are both comprised primarily of stocks or stream systems, respectively, from west of the Cascade Mountains.

B. Between Years Comparisions

Meristic Characters

We could discriminate between the different stocks of steelhead despite between year variation for all of the characters except pelvic fin rays. For each of the nine stocks in Table 11, we combined the year classes and used analysis of variance to determine if the year to

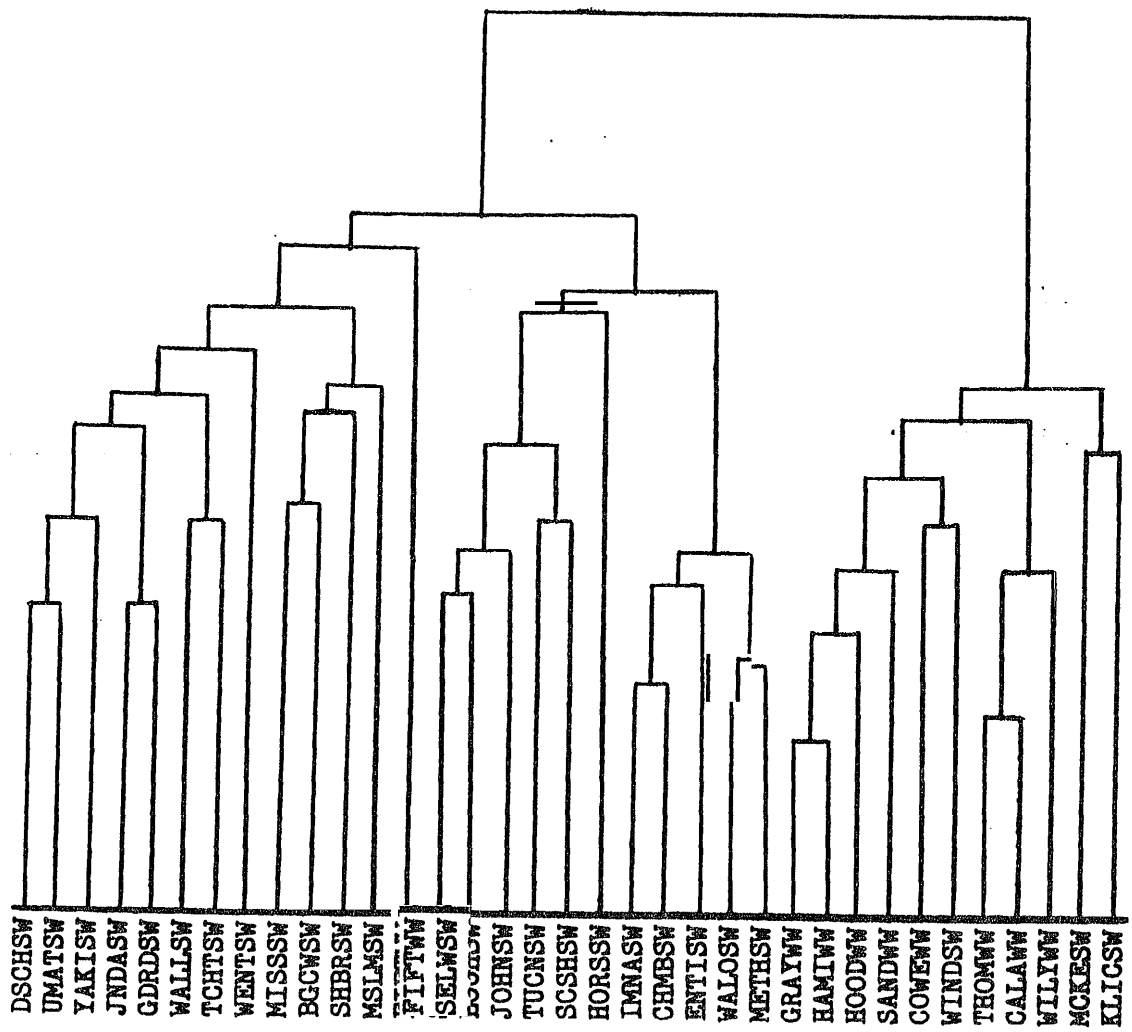

Figure 23. Wild steelhead trout cluster analysis using biochemical, body shape, meristic and life history characters. Clustering strategy is correlation, See Table 3 for key to stock names.

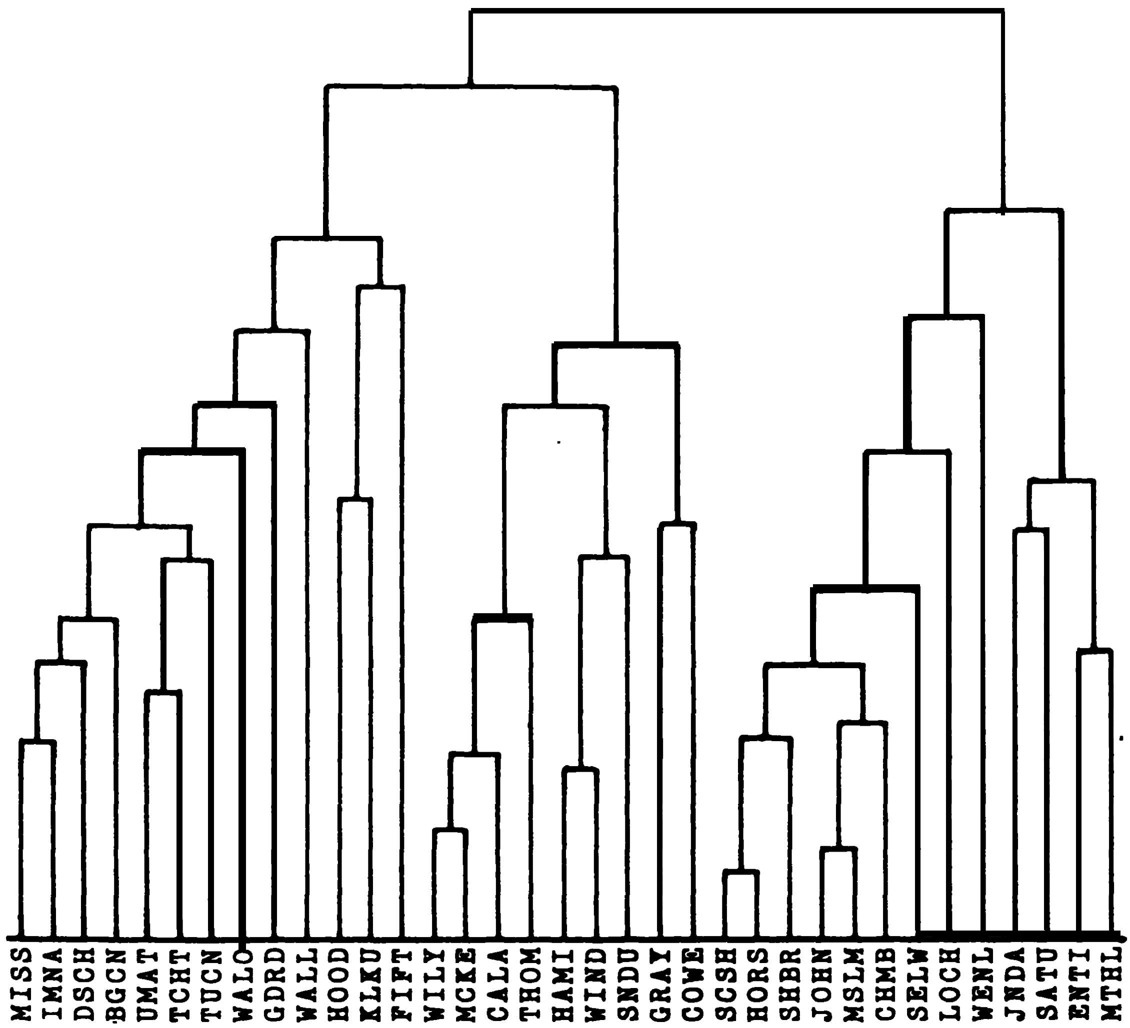

Figure 24. Cluster analysis of spawning streams of steelhead trout based on environmental characters. Clustering strategy is correlation. The streams are from left to right Mission Creek, Imnaha River, Deschutes River, Big Canyon and Cottonwood creeks, Umatilla River, Touchet River, Tucannon River, Wallowa and Lostine rivers, Grande Ronde River, Walla Walla River, Hood River, Klickitat River, Fifteenmile Creek, Wiley Creek, McKenzie River, Calapooya River, Thomas Creek, Hamilton Creek, Wind River, Sandy River, Grays River, Coweeman River, Secesh River, Horse Creek, Sheep and Bargamin creeks, Johnson Creek, Middle Fork of the Salmon River, Chamberlain Creek, Selway River, Lochsa River, Wenatchee River, John Day River, Satus Creek (Yakima River system), Entiat River, and Methow River.

Table 11. Significant differences between year classes of steelhead trout for meristic characters. An "*" indicates a statistically significant difference (p s 0.5). Blank spaces do not indicate missing data but rather indicate lack of significant differences.

STEELHEAD STOCK	FORM	SCALES IN LATERAL SERIES	SCALES ABOVE LATERAL LINE	ANAL RAYS	DORSAL RAYS
MARION FORKS HATCH.	W				*
MCKENZIE RIVER	S	*			
WASHOUGAL HATCHERY	S				*
FIFTEENMILE CREEK	W		*		
UMATILLA RIVER	S				
GRANDE RONDE	S				
WALLOWA LOSTINE	S				
IMNAHA RIVER	S				
YAKIMA RIVER	S				

STEELHEAD STOCK	FORM	PELVIC RAYS	PECTORAL RAYS	GILL RAKERS	LEFT BRANCHIOSTEGALS	VERTEBRAE
MARION FORKS HATCH.	W					
MCKENZIE RIVER	S					
WASHOUGAL HATCHERY	S		*			
FIFTEENMILE CREEK	W				*	
UMATILLA RIVER	S	*				
GRANDE RONDE	S		*			
WALLOWA LOSTINE	S					
IMNAHA RIVER	[illegible]					
YAKIMA RIVER	E					

year variation was the sole cause of the differences among the stocks. The results indicate that the between year variation is only part of the total variation and that there are differences among the stocks for all of the meristic characters except for pelvic fin rays. Because the ANOVA test on pelvic fin rays was not significant we did not include it in further analysis of steelhead.

The number of anal fin rays and vertebrae are stable and did not vary between year classes of steelhead trout (Table 11). The other meristic characters are variable between year classes of the same stock for steelhead. In the comparision between year classes of nine steelhead stocks, dorsal fin rays and pectoral fin rays were different between years in two stocks, and scales in the lateral series, scale rows above the lateral line, pelvic fin rays, gill rakers and branchiostegal rays were each different between year classes of one stock. The level of between year variation is similar between winter and summer steelhead and between hatchery and wild stocks of steelhead.

Body Shape Characters (Morphology)

Differences among steelhead stocks were detected for each of the body shape characters when the year classes for each stock were combined. This signifies that for each body shape character the between years variation is only part of the total variation and that there are differences among the stocks.

Maxillary length is stable and did not vary between year classes of steelhead trout. All of the other body shape characters differed between year classes of the same stock of steelhead trout for at least one of the eight stocks tested (Table 12). The most variable body shape character was the distance from the top of the head to the insertion of the pectoral fin which was different between year classes for three stocks. The level of between year variation appears to be similar for winter and summer steelhead.

Electrophoretic Characters

Electrophoretic characters can be used for classification purposes despite between year variation. Fourteen percent of the comparisons with chi-square tests were significantly different between year classes of the 12 stocks tested (Table 13) however, the variation between years is small compared to variation among stocks. The most variable system was lactate dehydrogenase-4 which was significantly different between year classes in four out of eight stocks tested. The most stable enzyme system was aconitate hydratase which was variable between year classes for one of fifteen stocks tested. Hatchery stocks were variable between years in 16% of the enzyme systems as compared to 8% for wild stocks. Summer stocks were variable between years in 8% of the enzyme systems tested as compared to 18% in winter steelhead stocks.

Table 12. Significant differences between year classes of steelhead trout for morphometric characters. An "*" indicates a statistically significant difference (p < 0.5). Blank spaces do not indicate missing data but rather intimate lack of significant differences.

STEELHEAD STOCK	FORM	SNOUT TO TOP OF HEAD (1x2)	SNOUT TO OPERCULA (1x16)	MAXILLARY LENGTH (1x17)	HEAD DEPTH-1 (2x14)	HEAD DEPTH-2 (2x15)	CAUD.PED LENGTH (4x7)
YAKIMA RIVER	S				*		
FIFTEENMILE CREEK	W				*		
TUCANNON RIVER	S						
GRANDE RONDE RIVER	S						
UMATILLA RIVER WILD	S				*		
IMNAHA RIVER	S					*	
WALLOWA-LOSTINE R.	S	*				*	
THOMAS CREEK	W						

STEELHEAD STOCK	FORM	CAUD.PED DEPTH-1 (4x9)	CAUD.PED DEPTH-2 (6x8)	CAUD.PED DEPTH-3 (6x9)	ANAL BASE (9x10)	HEAD WIDTH	INTER-ORBITAL WIDTH
YAKIMA RIVER	S						
FIFTEENMILE CREEK	W		*	*		*	
TUCANNON RIVER	S						
GRANDE RONDE RIVER	S				*		
UMATILLA RIVER WILD	S						
IMNAHA RIVER	S	*			*		
WALLOWA-LOSTINE R.	S			*			
THOMAS CREEK	W	*					

Table 13. Between year variability for enzyme gene frequencies of steelhead trout as judged by chi-square tests.

STEELHEAD STOCKS	Enzyme systems with statistically significant differences in gene frequencies	Enzyme systems with similar gene frequencies
BIG CREEK HATCHERY WINTERS, 84 vs. 85	AH	IDDH, MDHp, LDH-4, MDH-34
EAGLE CREEK HATCH. WINTERS, 83 vs. 85	LDH-4	AH, IDDH, MDH-34,SOD
THOMAS CREEK WILD WINTERS, 83 vs. 84	IDDH	LDH-4, SOD
THOMAS CREEK WILD WINTERS, 84 vs. 85	LDH-4	IDDH, SOD
THOMAS CREEK WILD WINTERS, 83 vs. 85	IDDH	LDH-4, MDH-34, SOD
WILEY CREEK WILD WINTERS, 84 vs. 85	LDH-4	AH, AGP, MDH-34, SOD
CALAPOOIA RIVER WILD WINTERS, 83 vs. 84		LDH-4, SOD, IDDH
LEABURG HATCHERY SUMMERS, 83 vs. 85	AH, AGP	IDDH, LDH-4, MDHp, GPI-3, SOD, MDH-34
WIND RIVER WILD SUMMERS, 84 VS. 85		AH, IDDH, LDH-4, SOD
WASHOUGAL HATCH. SUMMERS, 83 VS. 85	AGP, GPI-3, MDHp, MDH-34, SOD	AH, IDDH, LDH-4

Table 13. (Continued).

STEELHEAD STOCKS	Enzyme systems with statistically significant differences in gene frequencies	Enzyme systems with similar gene frequencies
TUCANNON RIVER WILD SUMMERS, 84 vs. 85		AH, IDDH, LDH-4, MDH-34, DPEP, SOD
ROUND BUTTE HATCH. SUMMERS, 84 vs. 85	LDH-4	AH, CK, DPEP, IDDH, SOD
JOHN DAY RIVER WILD SUMMERS, 84 vs. 85		AH, IDDH, DPEP, LDH-4, MDH-34, SOD
FIFTEEN MILE CREEK WILD WINTERS, 83 vs. 85	SOD	AH, IDDH, LDH-4, MDH-34
WALLOWA-LOSTINE R. WILD SUMMERS, 83 vs. 84		AH, LDH-4, SOD IDDH, MDH-34
IMNAHA RIVER WILD SUMMERS, 83 vs. 84		IDDH, LDH-4 AH, SOD
YAKIMA RIVER WILD SUMMERS, 83 vs. 84		LDH-4, DPEP, AH, IDDH, MDH-34, SOD
GRANDE RONDE RIVER WILD SUMMERS, 83 vs. 84		AH, DPEP, SOD

C. Incubation Temperature and Meristic Characters

Differences in water temperature during incubation does not explain the differences found among the hatchery stocks of steelhead trout in the number of gill rakers, vertebrae, pectoral fin rays, dorsal fin rays and anal fin rays (Table 8). The regression slopes for scales in she lateral series, scales above the lateral line, pelvic fin rays and branchiostegal rays were all significantly different from zero indicating that the water temperature during incubation has an impact on the branchiostegal rays, pelvic rays and scale counts, however the impact is limited. The correlation coefficients ranged from 0.69 for scales in the lateral series to -0.58 for branchiostegal rays, thus, water temperature during incubation accounts for less than 50% of the variation of these characters among the stocks.

D. Validation of Body Shape Characters

Truss type measurements in the caudal peduncle region of steelhead trout are useful for our analysis because these measurements are not affected by condition factor (Figures 25 and 26). Characters associated with the head region and some of the classical body measurements may also be useful although the results were not as consistant between size groups as were the truss type measures in the caudal peduncle region (Figure 26).

Truss type measures in the abdominal region are greatly affected by condition factor in steelhead trout and should not be used in the

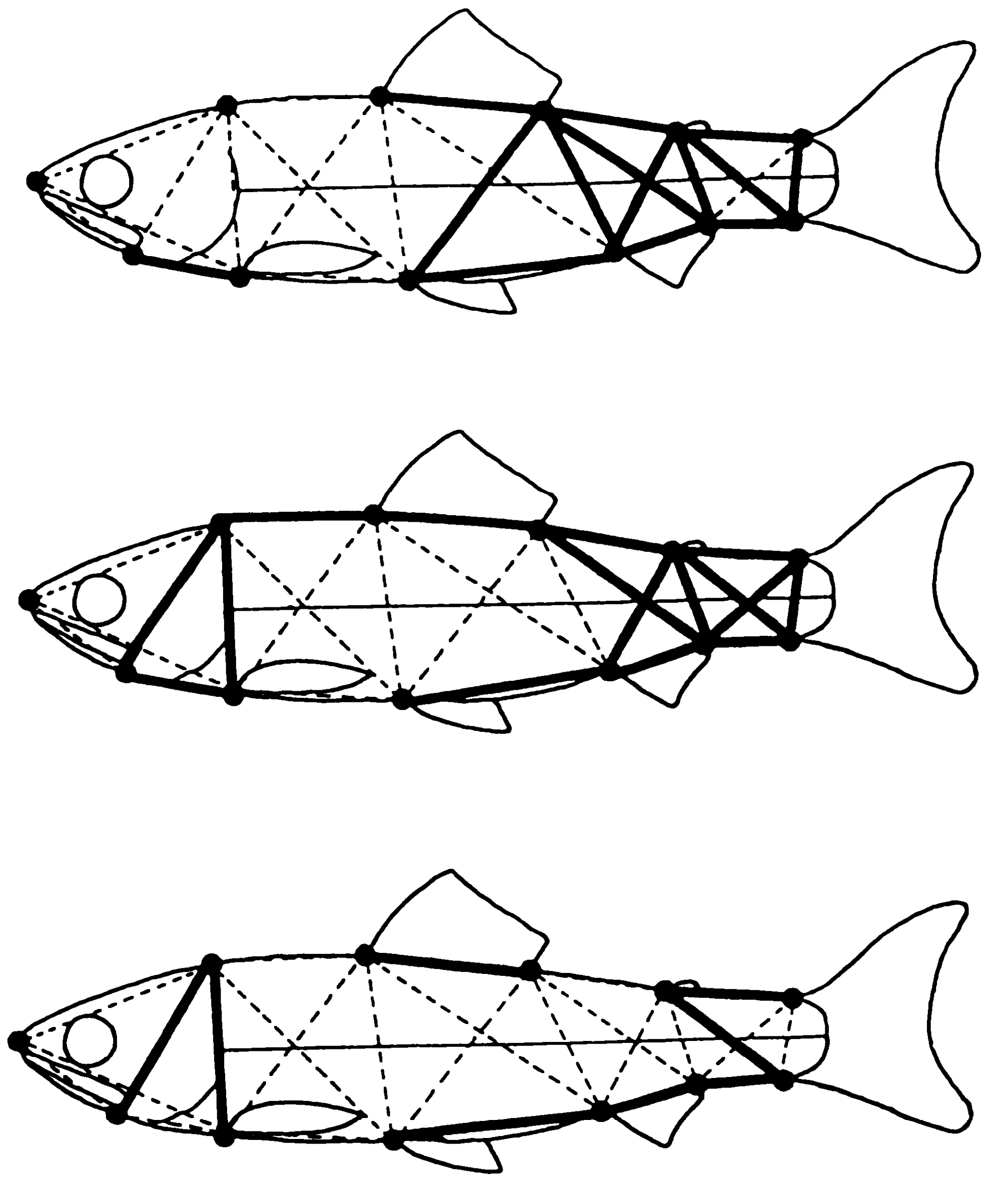

Figure 25. Truss-type measurements of a) small (x = 6.4cm), b) medium (x = 7.1cm) and c) large (x = 10.2cm) juvenile steelhead. Solid lines indicate body shape characters that do not differ (p < .95) between steelhead trout with high and low condition factors. Dotted lines indicate characters which had statistically significant differences between steelhead trout with high and low condition factors.

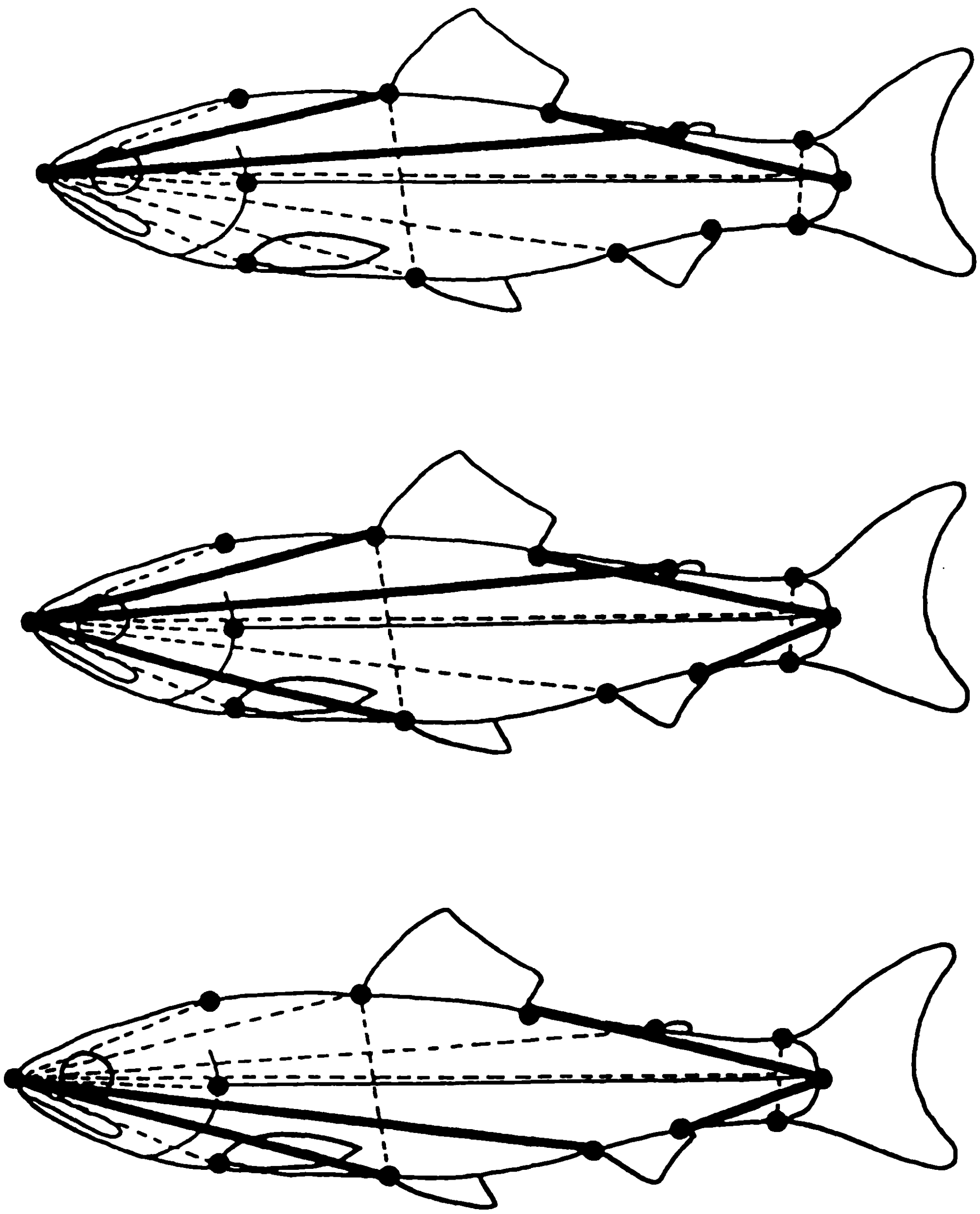

Figure 26. Classical measurements of a) small (x = 6.4cm, b) medium (x = 7.lcm) and c) large (x = 10.2cm) juvenile steelhead. Solid lines indicate body shape characters that do not differ (p < .95) between steelhead trout with high and low condition factors. Dotted lines indicate characters which had statistically significant differences between steelhead trout with high and low condition factors.

comparison among stocks. Based on these results, we included only those morphometric characters in the head and caudal peduncle region that are independent of condition factor for our final analysis.

E. Discrimination Power of Stock Characteristics

All of the meristic and body shape characters have useful information for discriminating among the stocks. Significant differences (p = .99) for each body shape and meristic character existed among the 57 hatchery and wild steelhead stocks from three brood years. There are differences among the stocks for each body shape or meristic character after correlations with other aspects of body shape or other meristic characters are taken into account. These conclusions are based upon analysis of covariance.

Several of the characteristics of stocks are associated with certain habitat types (Table 14). In general, steelhead stocks from east of the Cascades had higher frequencies of the common alleles of glycerol-j-phosphate dehydrogenase, malate dehydrogenase and malate dehydrogenase (NADP+), lower frequencies of the common alleles for L-lactate dehydrogenase, superoxide dismutase and aconitate hydratase, higher scale numbers in the lateral series and above the lateral line, and greater dorsal fin heights. These stock characters are correlated with stream characters that reflect the differences east and west of the Cascades. Stream systems from east of the Cascades tend to 1) be further from the mouth of the Columbia (distance), 2) have drier and colder climates (precipitation, number of frost-free days and minimum

Table 14. Correlation coefficients between the characteristics of wild steelhead trout and the environmental characteristics of their respective stream systems. Only correlation coefficients greater than or less than + 0.6 are listed.

STOCK CHARACTERS	ENVIRONMENTAL CHARACTERS	CORRELATION
ALPHA-GLYCEROPHOSPHATE DEHYDROGENASE	ANNUAL PRECIPITATION	-0.652
	ANNUAL RUNOFF	-0.607
L-LACTATE DEHYDROGENASE	ANNUAL PRECIPITATION	0.732
	ANNUAL RUNOFF	0.671
	ELEVATION	-0.696
	DISTANCE TO COL. MOUTH	-0.846
	ANNUAL FROST-FREE DAYS	0.684
	MINIMUM AIR TEMPERATURE	0.821
ACONITATE HYDRATASE	MINIMUM AIR TEMPERATURE	0.618
MALATE DEHYDROGENASE 3-4	ANNUAL PRECIPITATION	-0.731
	ANNUAL RUNOFF	-0.680
	ELEVATION	0.613
	DISTANCE TO COL. MOUTH	0.727
	ANNUAL FROST-FREE DAYS	-0.645
	MINIMUM AIR TEMPERATURE	-0.770
SUPEROXIDE DISMUTASE	ANNUAL PRECIPITATION	-0.825
	ANNUAL RUNOFF	-0.828
	ELEVATION	0.636
	DISTANCE TO COL. MOUTH	0.708
	ANNUAL FROST-FREE DAYS	-0.616
	MINIMUM AIR TEMPERATURE	-0.756
MALATE DEHYDROGENASE (NADP+)	ANNUAL PRECIPITATION	-0.625
	DISTANCE TO COL. MOUTH	0.688
	MINIMUM AIR TEMPERATURE	-0.740
SCALES IN LATERAL SERIES	ANNUAL PRECIPITATION	-0.709
	ANNUAL RUNOFF	-0.765
	DISTANCE TO COL. MOUTH	0.677
	ANNUAL FROST-FREE DAYS	-0.616
	MINIMUM AIR TEMPERATURE	-0.764
SCALE ROWS	ANNUAL PRECIPITATION	-0.742
	ANNUAL RUNOFF	-0.743
	DISTANCE TO COL. MOUTH	0.660
	ANNUAL FROST-FREE DAYS	-0.601
	MINIMUM AIR TEMPERATURE	-0.786
GILL RAKERS	SLOPE OF MAJOR CONTRIB. DRAINAGE	0.643
DORSAL FIN HEIGHT	DISTANCE TO COL. MOUTH	0.602

annual temperature), 3) be higher in elevation, and 4) have lower runoff.

Eventhough there were several instances where relationships between the presence-absence type stream characters and the characters of wild steelhead stocks had values of the correlation coefficient greater than 0.6 most of these appear to be the result of chance. Because there are just two states for these stream characters, high correlation coefficients could be caused by small differences between the two states or by several unusual values.

F. Heterozygosity

The Idaho steelhead stocks grouping together in cluster 3 of Figure 19 had the highest average relative heterozygosity in a comparison to the other five steelhead clusters. The relative heterozygosity values ranged from 0.1026 for the stocks in cluster 3 to 0.0812 for the stocks in cluster 2 (Figure 19). There were no significant differences in comparisons of relative heterozygosity values between hatchery and wild stocks or between winter and summer stocks of steelhead.

G. Basibranchial Teeth

Two different types of basibranchial teeth were found in the steelhead samples. Several small teeth resembling those found in cutthroat trout (*S. clarki*) were found in 5% of the fish from the Sandy and Wind rivers. A single large basibranchial tooth similar to those found in redband trout (*S. sp.*) was found in fish from Hamilton Creek (5%), Horse Creek (5%), Middle Fork of the Salmon River (5%), Secesh River (5%), Coweeman River (12%), Umatilla River (5%), Wallowa-Lostine River (3%), and Hood River (10%). Sample sizes ranged from 12 to 40 fish.

DISCUSSION

Traditionally, fisheries biologist have thought of populations of steelhead trout and chinook salmon in terms of time of entry into the Columbia River system and the locations of their natal streams. In general, steelhead trout have been classified into two forms, summer steelhead which return to the Columbia River between March 15 and September 30 and winter steelhead which generally enter the Columbia after November 15 (Smith, 1969: Howell, 1985b). Chinook are classified into three forms: spring, summer and fall chinook. Spring chinook typically enter the Columbia River between March 15 and May 30, summer chinook enter the Columbia River between June 1 and July 30, and fall chinook enter the Columbia after August 1 (Burner, 1951: Howell, 1985a). The forms of steelhead and chinook are further divided into stocks based on the location of spawning areas which include hatchery facilities and unimpounded areas of the Columbia River and its tributaries (Larkin, 1972). These local stocks form the basis for our samples.

Classification of Stocks

Steelhead trout and chinook salmon stocks tend to be phenotypically similar to other steelhead or chinook stocks that originate from natal streams that are geographically close, regardless of time of freshwater entry. The greatest dissimilarities among steelhead stocks and among spring chinook are between stocks from east and west of the Cascade Mountains. Within these eastern and western groups of both chinook salmon and steelhead trout the subgroups of similar stocks tend to be from the same geographical area. For instance, stocks of the Willamette River are closely related, the Idaho stocks are closely related and, in chinook, the stocks that smolt as subyearlings from the upper and lower Columbia River are closely related. The primary exception to this trend is between stocks of spring and fall chinook in the upper Columbia River.

Clusters of phenotypes for each species are best explained on the basis of geographic proximity of natal streams rather than time of entry into freshwater. Winter and summer steelhead from west of the Cascade mountains closely resemble each other. Steelhead from Fifteenmile Creek, the only winter stock sampled from east of the Cascades, were more similar to other summer stocks east of the Cascades than to winter stocks from west of the Cascades. Allendorf (1975) and Chilcote et al. (1980) found that winter and summer steelhead stocks from the same drainage area were similar to each other using electrophoretic characters. Winter steelhead and summer steelhead from west of the Cascades tend to cluster separately, but these groupings better reflect differences between hatchery and wild steelhead stocks than differences between winter and summer steelhead. Both of the wild summer stocks from west of the Cascades closely resemble winter steelhead while winter and summer steelhead of hatchery origin are much alike.

Characters based on bodyshape were important for discriminating between the groups of hatchery and wild stocks. Hatchery fish have smaller heads and longer, deeper caudal peduncles than wild fish. On both sides of the Cascades, wild stocks of steelhead tend to cluster with wild stocks rather than hatchery stocks. The differences in body shape reflect differences in body proportion between hatchery and wild stocks and cannot be attributed to differences in condition factor because the morphological characters we used are independent of condition factor. Differences in body proportions between hatchery and wild stocks may be caused by rapid growth in the hatcheries or by other rearing conditions such as diet or slow water velocities. Growth rate can affect body shape by altering the timing of the transition from one growth stanza to another (Huxley, 1932 and Martin, 1949 as cited in Barlow, 1961). According to Barlow (1961), a stanza is a period of time when the relative growth of a body part is constant. This relationship between the body part and the body as a whole changes abruptly during the transition period. Hatchery smolts are reared to smolt size in one year as compared to two or three years that wild stocks require to reach smolt size, thus, hatchery stocks probably experience more rapid growth which may affect their body shape. Diet could also alter body proportions of hatchery stocks as compared to wild stocks. Romanov (1984) found that artificial diets may lead to abnormal skull morphology because the juveniles are feeding on smaller than normal food particles.

The differences in body proportion of hatchery stocks compared to wild stocks could result in genetic changes in the hatchery steelhead stocks. The smaller heads and larger caudal peduncle of hatchery relative to wild smolts may affect their performance and thus their survival after they are released from the hatchery. Also, because of differences in body shape of hatchery stocks, the direction and/or the type of selection acting upon the hatchery stocks may be different from those forces acting upon the wild steelhead.

Spring chinook stocks have stronger affinities to stocks that originate on the same side of the Cascades, irrespective of run timing, than to those stocks originating on the other side of the Cascade Range. Therefore, spring chinook from west of the Cascades are closely alligned to fall chinook in the same or neighboring stream systems. By the same token, spring chinook stocks of the Salmon River, Idaho, have stronger affinities to Salmon River summer chinook stocks than to spring chinook stocks from west of the Cascade Mountains.

Summer chinook can also be divided into two main groups: 1) populations in the upper Columbia River that smolt as subyearlings and grouped with fall chinook stocks of the middle and lower Columbia; and 2) summer chinook stocks from the Salmon River, Idaho, which smolt as yearlings and are similar to spring chinook stocks from Idaho.

Whereas spring and summer chinook stocks can be divided into subgroups, fall chinook appear to comprise one large diverse group that is not easily subdivided into smaller units by cluster analysis. However, the fall chinook from the upper Columbia River and fall chinook from the lower Columbia River differ in one significant character. Upper Columbia gene frequencies of the common allele of tripeptide aminopeptidase is higher in the stocks from the lower Columbia River than in the fall chinook stocks from the upper Columbia River (Figure 27).

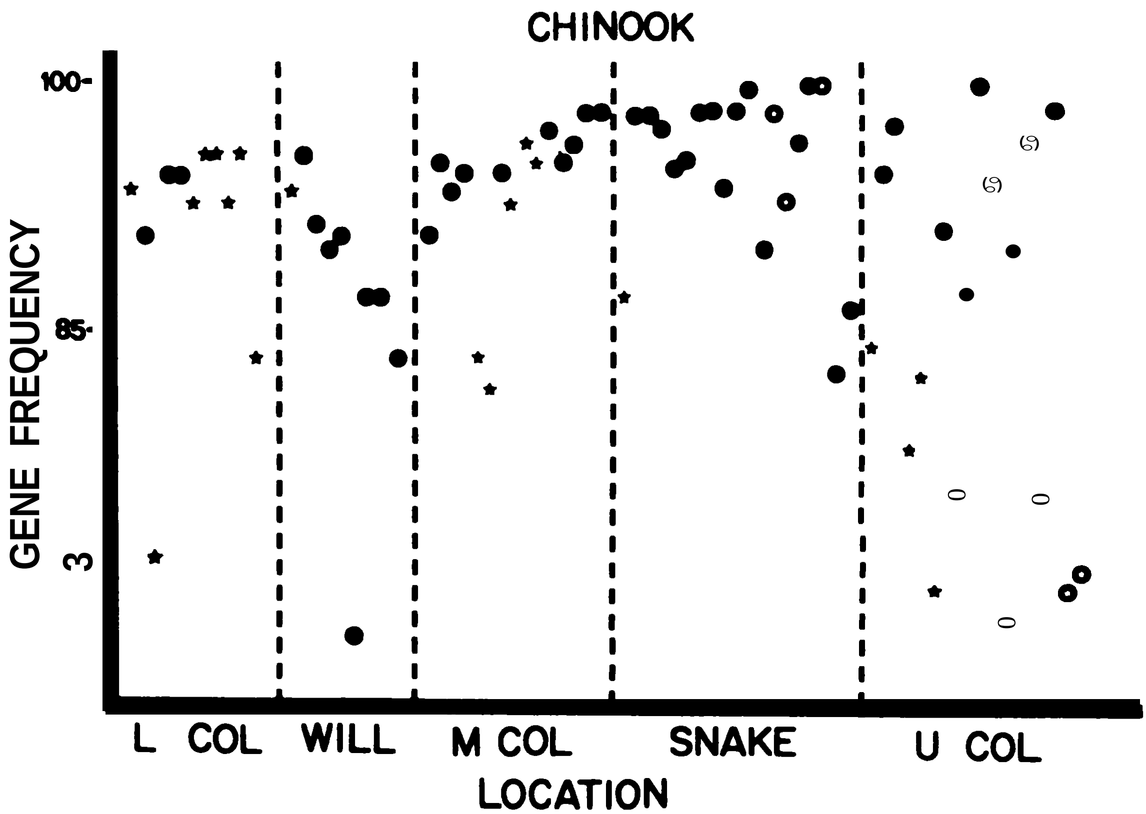

Figure 27. Frequency of common allele of tripeptide aminopeptidase vs. geographical zone in spring (dots), summer (circled stars) and fall (stars) chinook stocks. Stocks and geographical zones are in order from lower to upper Columbia but distances within and between geographical zones are not to scale.

Hatchery and wild chinook stocks are not as easily differentiated by body shape as the hatchery and wild steelhead. The major difference between hatchery and wild chinook is that hatchery chinook have shorter heads and shorter maxillary bones. There are several possible explanations as to why there are stronger differences between hatchery and wild steelhead than between hatchery and wild chinook. One difference between steelhead and chinook that can account for this phenomenon is growth rate. Juvenile chinook apparently can maintain wild-type body proportions under hatchery rearing conditions because they can also grow rapidly in the wild. Wild chinook salmon generally smolt as subyearlings or yearlings unless they are unable to reach adequate size because of cold water temperatures or lack of food. Steelhead trout rearing in the same areas generally take at least two years to reach smolt size, whereas in the hatchery environment both chinook and steelhead are reared to smolt size in one year.

There are similarities in the classifications derived for chinook salmon and steelhead trout. Like steelhead, chinook stocks of different forms (ie. times of freshwater entry) originating from geographically close stream systems closely resemble each other, and genetic similarity appears to be independent of run timing. This does not hold for upper Columbia spring chinook and upper Columbia fall or summer chinook. Spring and fall chinook from west of the Cascade Mountains are grouped together, spring and summer chinook in the Salmon River are grouped together and fall and summer chinook in the upper Columbia are also closely alligned.

It is thought that steelhead stocks from east and west of the

Cascades developed from two different trout-like ancestors which may explain the east-west differences in meristic and electrophoretic characters (Allendorf 1975 and Behnke 1979b). However, chinook salmon also have differences in meristic (Figure 15) and electrophoretic characters (Figures 16 - 18) between stocks from east and west of the Cascades. Both steelhead and chinook have higher numbers of vertebrae and scales in the lateral series in stocks found east of the Cascade Mountains compared to stocks found west of the Cascade mountains. This could indicate that chinook also developed from different progenitors from each side of the Cascades. However, this is more unlikely than for steelhead. Another arguement could be developed suggesting within basin divergence of the two steelhead and two chinook types. It would be extremely unlikely for two invasions of two species into the Columbia basin with identical meristic patterns. In fact, different habitat types encountered east and west of the Cascades might be imposing parallel selective pressures upon the two species causing the within species divergence.

Basibranchial teeth in some of the steelhead stocks could be the result of introgression by redband trout or cutthroat trout genes, or they could be the result of redband trout ancestry in steelhead stocks. In either case it appears that redband trout are widely distributed throughout the Columbia basin. Basibrancial teeth maybe present in more stocks then is indicated by our results. Larger sample sizes than what we needed for morphometric analyses (20 fish per stock) would probably increase the proportion of stocks having at least some individuals with basibranchial teeth and provide a more accurate description of the historic distribution of redband trout in the Columbia basin. The presence of cutthroat trout-type basibranchial teeth in steelhead stocks suggests that there is some introgression by cutthroat into the steelhead stocks west of the Cascade Mountains. Cutthroat trout are present in most of the streams of the lower Columbia River and their numbers are supplemented by hatchery outplants.

The characters employed in this study can be used to estimate the intraspecific genetic dissimilarity of the stocks in the Columbia River system because they are genetically based descriptors of chinook salmon and steelhead trout stocks. In addition, our results indicate that each meristic and body shape character is important for discriminating among the stocks after the correlations with other meristic or body shape are accounted for. That is, each character, meristic or body shape, has information for discriminating among stocks that is not present in all of the other meristic characters or body shape characters, respectively. However, we must consider the following three questions concerning the use of these characters in our analysis: 1) Is the source of variation for each character due to among stock variation or within stock variation?; 2) What are the environmental effects on each of the characters?; and 3) Is selection acting on the characters or are they selectively neutral?

Between year variation does not account for differences among the stocks for all of the meristic and body shape characters with the exception of pelvic fin rays in steelhead trout. The differences between year classes of the same stock in biochemical (i.e.

electrophoretic) characters is small compared to the variability among the stocks. Parkinson (1984) in a study on steelhead stocks also found between year differences of biochemical characters and the between year differences only formed a part of the total variation among the stocks. The utility of biochemical characters to discriminate among stocks is even more apparent when one considers that we employed only those enzyme systems with considerable variability (i.e. those that are not "fixed").

The between years variation that we identified for meristic, body shape and biochemical characters could be caused by selection, environmental effects, or year to year differences in stock composition. Selection may be a factor in some of the year to year variation in stock characteristics because the environments are variable from year to year. In particular, wild stocks have a high mortality rate during the freshwater rearing period, so variation in the stream environments could result in differences between years. Hatchery stocks, however, generally have high mortality after release from the hatchery (Helle 1981) so variable ocean conditions could lead to shifts in genotype.

Environmental effects are a possible but perhaps minor cause of between year variation. Water temperature during incubation does have an effect on meristic counts (Taning, 1952; Seymour, 1959) but our evidence suggests that this effect is probably small compared to the among stock variation. We have found that water temperature is not correlated with the variation in the majority of meristic characters. Scales in the lateral series, scales above the lateral line and branchiostegal rays in steelhead were significantly (p = 0.95) correlated with incubation temperature but the amounts of variation accounted for by the regression were less than 50% as indicated by the coefficient of variation (Snedecor and Cochran 1967).

The observed between years variation could be caused by changes in stock composition. The composition of a stock can be changed by founder effects and random drift if the spawning population is small (Hartl l981), or by man through the introduction of foreign stocks. An example of a chinook stock that was changed by man's introduction of a foreign stock is found at Speelyai hatchery, located on the Lewis River in the lower Columbia River Basin. The Speelyai and Kalama River Hatchery spring chinook are managed as substocks of the Cowlitz River spring chinook since both hatcheries have received broodstock from the Cowlitz Hatchery (Howell et al. 1985a). However, the Speelyai Hatchery stock is more like the spring chinook stocks from east of the Cascade Mountains and is dissimilar to the Cowlitz Hatchery spring chinook and the Kalama Hatchery spring chinook stocks (Figure 7). Speelyai hatchery spring chinook had the highest vertebrae number (Figure 15) and the lowest gene frequency for phosphoglycerate kinase (Figure 16) and mannose-6-phosphate isomerase (Figure 17) of any stock in the lower Columbia River. The number of vertebrae and the gene frequencies of phosphoglycerate kinase and mannose-6-phosphate isomerase are similar to those of spring chinook from east of the Cascade Mountains. Speelyai Hatchery has received juvenile spring chinook from Carson and Klickitat hatcheries (Howell et al. 1985a), both of which are considered part of the group of spring chinook from east of the Cascade

Mountains (Figure 7). Therefore, it appears that the stock composition of Speelyai Hatchery has been changed by the introduction of a foreign stock by man.

We believe that the genetic component accounts for most of the among stocks variation, even for scales in the lateral series and scales above the lateral line in steelhead. Both of these characters were significantly correlated with incubation temperature which would suggest an environmental effect, however, these correlations may be spurious. The correlations of scales in the lateral series and scales above the lateral line with incubation temperature are positive but, according to Jordan's Law (Jordan 1894; Hubbs and Hubbs 1945; Barlow 1961), one would expect a negative relationship, that is, higher counts at lower temperatures. Temperature effects on meristic characters may be more complex than a simple linear relationship given the more recent finding of Seymour (1959) and Lindsey et al. (1984). The significant correlations of the meristic characters with incubation temperature found by us may be related to well water temperatures at different hatcheries. In particular, several hatcheries east of the Cascades use well water for egg incubation that is warmer than the water used west of the Cascades. This temperature gradient matches the gradient of scale counts found in wild stocks i.e., higher counts east of the Cascade Mountains. For example, Big Creek Hatchery stock and Marion Forks Hatchery stocks from 1983 and 1985 incubated at the lowest temperature (8.3, 5.0 and 5.0) and had an average of 131.9 scales in the lateral series and 25.8 scales above the lateral line. Pahsimeroi, Sawtooth and Hells Canyon hatchery stocks experienced the highest incubation temperatures (14.4 C - 15.0 C) and the fish averaged 150.0 scales in the lateral series and 29.9 scales above the lateral line. Wild stocks from east of the Cascades however, had higher average scale counts (150.2 scales in the lateral series and 31.0 scales above the lateral line) and were probably incubated at cooler temperatures than the hatchery stocks on well water. The scale counts of these upriver wild stocks were higher, not lower as would be predicted by the positive relationship found with the data on hatchery stocks. Thus it appears that the apparent correlation between incubation temperature and the scale counts is not a cause and effect relationship. Consequently, the variation in meristic characters most likely reflects real genetic variation among the stocks that happened to match the distribution of hatchery incubation temperatures.

Characters associated with certain aspects of body shape have a genetic basis in salmonids as shown by Riddell et al. (1981), and Taylor and McPhail (1985a). However, our results suggest that environmental effects may also be a factor in determining the body shape of hatchery and wild stocks. We are as yet unable to determine to what extent differences in body shape between hatchery and wild fish are genetically influenced. Characters based on body shape may be useful for comparing stocks from like environments, such as among wild stocks or among hatchery stocks.

Biochemical gene frequencies tend to have geographic patterns of variation; that is, neighboring stocks of the same form generally have similar gene frequencies (Utter, 1981). This pattern of variation could be caused by selection since neighboring stream systems tend to be similar. Similar streams would have similar selection pressures and similar environmental variability, hence there would be similar phenotypes of the salmonids. However, biochemical characters are generally thought to be selectively neutral (Kimura 1968) although there is some evidence to the contrary (see Allendorf and Utter [1979] for a review). If in fact the biochemical characters are selectively neutral, any interstock variation would be the result of random drift and/or founder effect. There is some evidence in our data suggesting that biochemical gene frequencies may indeed be selectively neutral. In the case of chinook salmon, spring chinook in the upper Columbia have gene frequencies similar to those of neighboring spring chinook and dissimilar to those of neighboring fall and summer chinook for aconitate hydratase, mannose phosphate isomerase and phosphoglycerate kinase whereas west of the Cascades, spring and fall chinook have similar gene frequencies for each of these enzyme systems (Figures 16, 17 and 18). If selection were acting on these enzyme systems we would expect parallel evolutionary traits because of the high degree of similarity in habitats used by spring chinook stocks both east and west of the Cascade Mountains. Thus it is possible that the gene frequencies of aconitate hydratase, mannose phosphate isomerase, and phosphoglycerate kinase could be the result of founder effect and/or random drift and that they are not affected by selection. Enzyme systems such as tripeptide aminopeptidase in fall chinook and glycerol-j-phosphate dehydrogenase, aconitate hydratase, dipeptidase, superoxide dismutase and L-lactate dehydrogenase in steelhead exhibit gradients throughout the Columbia. These gradients could be maintained by either selection or by straying with neutral alleles (Kimura and Marayama, 1971).

The reason for the variation in meristic characters among stocks is as yet unclear. Neutrality or adaptiveness has not been firmly demonstrated. In chinook, numbers of vertebrae (Figure 15) covary with phosphoglycerate kinase (Figure 16), aconitate hydratase (Figure 18) and mannose phosphate isomerase (Figure 17). Spring and fall chinook from west of the Cascade Mountains have similar numbers of vertebrae and similar gene frequencies of phosphoglycerate kinase, aconitate hydratase and mannose-6-phosphate isomerase, while east of the Cascades there are differences between the spring chinook stocks and the fall chinook stocks for these characters. Intuitively, meristic characters should be subject to selection since anatomy most likely would affect the physical performances of the fish. For example, swimming should be affected by number of vertebrae and fin rays while feeding behavior is often influenced by number of gill rakers.

Characters associated with body shape and fin size are probably affected by selection. Like meristic characters, morphological characters should affect the performance of fish. Selective advantages of certain body morphs have been hypothesized by Riddell and Leggett (1981), Carl and Healey (1984) and Taylor and McPhail (1985a). Spring chinook, which smolt as yearlings, generally have larger paired and median fins than neighboring fall chinook or summer chinook from the upper Columbia river which smolt as subyearlings (Table 15). Apparently, chinook stocks which rear in the streams for a year may need larger fins for feeding and maintaining position in the stream

TABLE 15. Average dorsal and anal fin heights and pectoral and pelvic fin lengths and standard error of the means (in parentheses) for wild lower Columbia River chinook (WEST)and wild upper Columbia River chinook (EAST). A dash ("-") indicates missing data.

STOCK NAME	FORM	DORSAL FIN	ANAL FIN	PECTORAL FIN	PELVIC FIN
WEST					
THOMAS CREEK	SP	12.9 (0.23)	8.7 (0.22)	14.1 (0.11)	11.5 (0.12)
COLLOWASH R.	SP	12.8 (0.23)	8.3 (0.31)	14.6 (0.16)	11.5 (0.14)
CLACKAMAS R.	F	11.2 (0.19)	7.6 (0.14)	13.7 (0.18)	10.6 (0.18)
LEWIS RIVER	F	11.2 (0.22)	7.0 (0.13)	13.0 (0.12)	10.6 (0.16)
SANDY RIVER	F	10.9 (0.19)	7.7 (0.12)	14.6 (0.20)	11.4 (0.17)
EAST					
YAKIMA RIVER	F	14.6 (0.22)	6.7 (0.32)	12.7 (0.13)	9.7 (0.16)
YAKIMA RIVER	SP	12.5 (0.24)	7.8 (0.16)	14.6 (0.15)	11.4 (0.13)
WENATCHEE R.	su	10.8 (0.18)		13.3 (0.22)	10.8 (0.13)
WENATCHEE R.	SP	13.1 (0.13)	8.1 (0.12)	15.2 (0.24)	11.8 (0.16)
METHOW RIVER	su	10.5 (0.08)	7.1 (0.15)	13.2 (0.15)	10.2 (0.14)
METHOW RIVER	SP	13.0 (0.18)	8.3 (0.25)	14.8 (0.19)	11.6 (0.15)

environment as opposed to fall chinook which smolt as subyearlings and do not remain in the stream environment for as long. Carl and Healey (1984) also found that a chinook stock which smolted as yearlings had larger fins than two chinook stocks which smolted has subyearlings in the Naniamo River, British Columbia. We found that steelhead had larger fins, particularly the dorsal, in the stream basins that were further from the mouth of the Columbia River (Figure 28). The anal, pelvic and pectoral fins of steelhead also tend to be larger in fish further upstream from the mouth of the Columbia River. The statistically significant correlation coefficients of the fin lengths regressed on distance were 0.41, 0.43 and 0.57 respectively.

Many of the correlations between characteristics of the fish and characteristics of their natal streams might be attributed to either founder effect for selectively neutral characters or selection. In particular some of the isozyme gene frequencies and meristic characters differ sharply between stocks east and west of the Cascade. In both steelhead and chinook, the meristic and biochemical characters are usually correlated with those environmental characters that distinguish streams from east and west of the Cascades (Tables 9 and 14). We found that these stream characters include precipitation, elevation, distance from the mouth of the Columbia, number of frost free days and minimum annual air temperature. While it may very well be that these characters of the stocks are the result of selection, it also seems likely, based on the patterns of variation discussed earlier, that they are to some extent selectively neutral.

The variety of characters we have used improves our analysis of

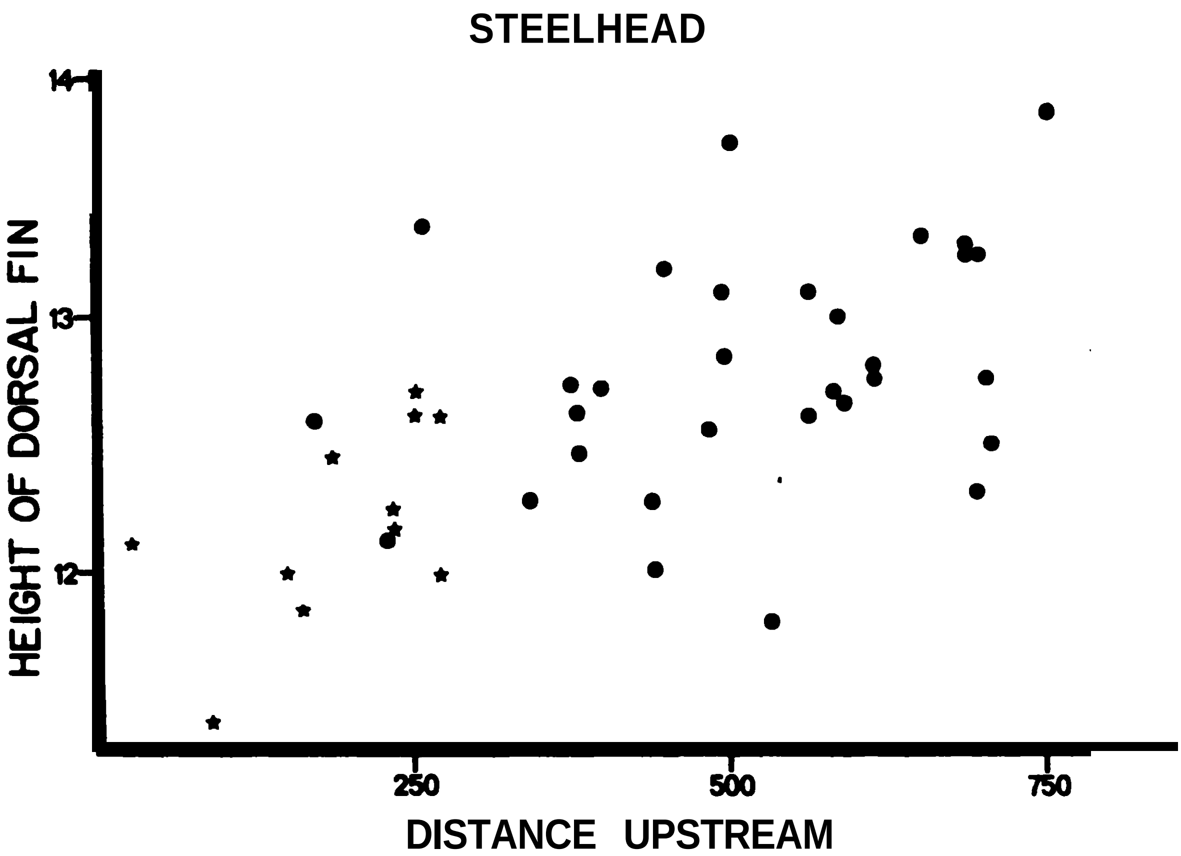

Figure 28. Height of dorsal fin in wild summer (dots) and winter (stars) steelhead vs. distance of spawning grounds upstream from the mouth of the Columbia (miles).

the relationships among stocks in the Columbia River. We have sampled a larger portion of the total genome by using several types of characters to estimate genetic similarity than we would have gathered had we used just one type of character. Each type of character by itself presents a partial picture of the relationships among the stocks. Analysis of the relationships among stocks using biochemical characters alone delineated some of the important relationships seen in our analysis using all of the characters. Utter (manuscript in preparation) found three groups of chinook stocks in the Columbia River: 1) chinook from west of the Cascade Mountains; 2) chinook from east of the Cascade Mountains excluding the Snake River and 3) the Snake River. These results are consistent with our results except that we had more groups because we included more stocks in our analysis. Allendorf (1975) used biochemical characters to show that there were differences between steelhead from east and west of the Cascade Mountains. We have found that numbers of vertebrae in chinook and number of scales in the lateral series for steelhead also separate the stocks east and west of the Cascade Mountains. In addition, numbers of vertebrae discriminated between spring and summer chinook in the upper Columbia River. Thus biochemical and meristic characters reinforce the patterns observed if each character type was to be used alone (Figures 15 - 18). The similarity in classification derived from either biochemical or meristic characters increases our confidence in both types of characters, especially since meristic characters are polygenic and represent a larger portion of the genome than biochemical characteristics. Body shape characters helped discriminate between forms of chinook, but body shape may or may not be affected by the environment in steelhead stocks. Although fin lengths were not used in our analysis, they discriminated between fall and spring chinook from west of the Cascade Mountains where meristic and biochemical characters were not powerful enough to distinguish between the two forms. Thus, by using characters based on aspects of body shape, we have been able to obtain a more complete discrimination of the stocks and a more holistic picture of the relationships among the stocks.

Life history characters could also make an important contribution to classifying the stocks. However, for many characters adequate data for all of the stocks were not available. For instance, we are unable to compare the so called "A" and "B" steelhead stocks of the Snake River because there are not adequate data on years spent in the ocean for the wild steelhead stocks. Howell et al. (1985 a and b) has done an excellent job of compiling the known life history data and identifying areas in need of research. We believe that additional research on life history characters would further clarify important relationships among the stocks.

According to our results, the most important principle for managing stocks of Columbia River chinook salmon and steelhead trout is that geographically proximal stocks tend to be like each other. One exception to this principle is for steelhead stocks from tributaries of the Columbia near the crest of the Cascade Mountains. The dividing line appears to occur between the Klickitat River, which has a population of fish similar to stocks from west of the Cascade Mountains, and Fifteenmile Creek which is inhabited by a stock similar to those from east of the Cascade Mountains. However, the stream systems in our study that are located near the crest of the Cascade Mountains, including the Klickitat, Hood and Wind Rivers, have received hatchery steelhead smolts from stocks that are from west of the Cascade Mountains (Howell et al. 1985b). Consequently, the composition of the wild stocks from these streams may have been affected by these hatchery transplants and the original dividing line between the eastern and western groups of steelhead may actually have occured west of the Klickitat River.

Another exception to the use of geographically proximal stocks for stock management should be exercised when stocks of different forms (ie. run timing) are involved. Although time of return to freshwater appears to be relatively unimportant in taxonomic classification run timing should still be of concern in basing management decisions because it may be important to the fitness of the stocks as suggested by Ricker (1972). Divergences in time of return to freshwater may have developed after steelhead and chinook stocks were established in the Columbia as hypothesized by Behnke (1972b). Chinook and steelhead most likely have the genetic potential for expression of various run timing behaviors. Also, there are characters associated with each form that nay be important to survival. These associated characteristics include proportion of body fat in returning adults (Smith 1969), choice of spawning area (Howell et al. 1985a and b), and time of outmigration (Howell et al. 1985a and b). These characters were not in the current study because the data is not available, or because a genetic basis could not be proven. Another reason is that the large number of characters used in the analysis may have simply outweighed time of return, thus masking the discriminating power of time of return.

Similarity of the stream systems should be used in conjunction with the similarity of geographically proximal stocks when selecting donor stocks for transfer to other stream systems. In most cases stream systems that are near each other are similar. However, caution should be exercised concerning the transfer of a salmonid stock to nearby stream systems if the two stream systems are dissimilar. Parkinson (1984) found that even though biochemical gene frequencies tend to be similar over large geographical areas, stocks from adjacent streams can have significant differences in gene frequencies. The differences in gene frequencies in adjacent stocks suggests that there is little gene flow between the populations (Parkinson 1984) and therefore differences in stream characteristics such as temperature and flow regime, gradient, and stream size could affect the survival of a donor stock (Mayr 1971). Temperature and flow regime could affect the time of spawning, time of emergence and the time of outmigration (Riddell and Leggett 1981), all of which are important to the survival of a stock. Stream gradient and stream size may affect an introduced stock's ability to spawn or the ability of juveniles to rear in the new environment. Beecham (1984 and 1985) found differences in the morphology of chum salmon (0. keta) and pink salmon (0. gorbuscha) from large and small streams in British Columbia and Hjort and Schreck (1982) found differences between juvenile coho salmon from large and small stream systems in Oregon, Washington and California.

We have found differences among the stocks of chinook salmon and steelhead trout in the Columbia River system. However we do not know the relative importance of the characters used in the classification with respect to the fitness of the stocks. All of the characters have a genetic basis, but those that are influenced by selection have an intuitive appeal because of their importance to survival. If characters are neutral then it could be argued that their management value is primarily esthetic and that such characters do not need to be considered when managing the stocks. This points out the need for research to test for the adaptive significance of differences in character traits (e.g. see Suzumoto et al. 1972; Tsuyuki and Williscroft 1977; Northcote and Kelso 1981). However, even if selection is not operating on the extant phenotype of a character set, it is possible that selection could have been a factor in the past and/or could be a factor in the future. In Hartl's (1981) words there may be "a latent potential for selection," While the characters may be or appear to be neutral over a long period of time, unusual or periodic conditions may create situations where selection can take place. If selection is possible on all characters then the best management strategy is to act conservatively by considering all genetic characters as important. Our suggestion would be to maintain as many separate stocks or geographically proximal stocks as possible.

We have provided a biological basis for managing stocks as our contribution to the problem of managing the Columbia River chinook salmon and steelhead trout. Fishery managers must also face geopolitical (eg. treaty rights, state boundaries) and economic (eg.

commercial vs. sport) considerations while meeting their mandate to develop a fisheries management plan. When compromises must be made between biological and these other considerations we suggest that the Northwest Power Planning Council (NWPPC) develop geographical units for stock management. In order to be as biologically sound as possible, these geographical units should be kept small and only include streams that are similar.

We encourage the NWPPC and individual fisheries biologists to be as conservative as possible and to treat each stock as a separate entity whenever the various political, geographical and economic considerations allow them to do so. A conservative approach will protect the integrity of existing stocks and preserve management options for the future.

ACKNOWLEDGEMENTS

We would like to take this opportunity to thank our contracting officer, Gerry R. Bouck, for his efforts on our behalf. His administrative acumen maintained our funding during the course of the project and allowed us to concentrate on the biological aspects of the study.

A time conuming and technically difficult aspect of this project was the biochemical analysis. We would like to thank David Teel, Fred Utter and George Milner of the National Marine Fisheries Service in Seattle for allowing us to observe their techniques and for giving us the benefit of their experience. Without their contribution our start-up time would have been much longer.

Dennis Rondorf and Mike Dutchuk of the U.S. Fish and Wildlife service provided the space and manpower to help raise several fall and summer chinook stocks to a larger size at Willard National Fish Hatchery. Their generous contribution of time and effort is appreciated.

This project would not have been possible without interagency cooperation and the knowledge provided by biologist from throughout the Columbia River Basin. The following biologists provided information on history and either made available other information or helped us collect the many samples that were necessary to complete the project: Gary Anderson, Jerry Bauer, David Buchanan, Richard Carmichael, Errol Claire, William Day, John Haxton, Robert Hooton, James Hutchison, Brian Jonasson, Patrick Keeley, Bill Knox, Warren Knispel, Robert Lindsey, Nancy MacHugh, Julius Massey, James Newton, Erik Olsen, James Phelps, Kirk Schroeder, Eugene Smith, Mike Stratton, Walt Weber, Duane West, Joseph Wetherbee, Ron Williams, Stephen Williams, Charles Willis, Kenneth Witty, and Jeffery Zakel of the Oregon Department of Fish and Wildlife; David Fast, James Hallowed, Lynn Hatcher, Alan Luke, and Larry Wasserman of the Yakima Indian Nation; Wolfgang Dammers, Michael Eames, John Easterbrook, Hugh Fiscus, William Hopley and Don McIssac of the Washington Department of Fisheries; Bruce Crawford, James Cummins, James DeShazo, Joseph Foster, John Hisata, and Mark Shucks of the Washington Department of Game; Don Anderson, Bert Bowler, Mel Reingold and Russ Thurow of Idaho Department of Fish and Game; James Mullan and Curt Burley of the U.S. Fish and Wildlife Service; Dennis Dauble and William Hanf of Battelle Northwest; and Cris Stainbrook of the Warm Spring Indian Nation.

We appreciate the technical assistance provided by students and other staff members fo the Oregon Cooperative Fishery Research Unit.

LITERATURE CITED

Allendorf, F.W. 1975. Genetic variability in a species possessing extensive gene duplication: Genetic interpretation of duplicate loci and examination of genetic variation in populations of rainbow trout. Ph.D. thesis, Univ. of Washington, Seattle.

Allendorf, F.W., M. Mitchell, N. Ryman, and G. Stahl. 1977. Isozyme loci in brown trout (Salmo trutta): detection and interpretation from population data. Hereditas 86:179-190.

Allendorf, F.W., and S.R. Phelps. 1980. Loss of genetic variation in a hatchery stock of cutthroat trout. Trans. Am. Fish. Soc. 190:537-543.

Allendorf, F.W., and F.M. Utter. 1979. Population genetics, p. 407-454. In: W.S. Hoar, D.J. Randall, and J.R. Brett (eds.). Fish Physiology, Vol. 8. Academic Press, New York, NY.

Altukhov, Yu. P. 1981. The stock concept from the viewpoint of population genetics. Can. J. Fish. Aquat. Sci. 38:1523-1538.

Altukhov, Yu. P., and E.A. Salmenkova. 1981. Applications of the stock concept to fish populations in the USSR. Can. J. Fish. Aquat. Sci. 38:1591-1600.

Ayerst, J.D. 1977. The role of hatcheries In rebuilding steelhead runs of the Columbia Ever system, p. 84-88. In: E. Schwiebert (ed.). Columbia River salmon and steelhead. American Fisheries Society Special Publication No. 10. Washington, DC.

Barns, R.A. 1976. Survival and propensity for homing as affected by presence or absence of locally adapted paternal genes in two transplanted populations of pink salmon (Oncorhynchus gorbuscha). J. Fish. Res. Board Can. 33:2716-2725.

Barlow, G.W. 1961. Causes and significance of morphological variation in fishes. Syst. 2001. 10:105-117.

Beacham, T.D. 1984. Age and morphology of chum salmon in southern British Columbia. Trans. Am. Fish. Soc. 113:727-736,

Beacham, T.D. 1985. Meristic and morphometric variation in pink salmon (Oncorhynchus gorbuscha) in southern British Columbia and Puget Sound. Can. J. Zool. 63:366-372.

Behnke, R.J. 1972a. The rationale for preserving genetic diversity: examples of the utilization of intraspecific races of salmonid fishes in fisheries management. Proc. West. Assoc. State Game Fish Comm. 52:559-561.

Behnke, R.J. 1972b. The systematics of salmonid fishes of recently glaciated lakes. J. Fish. Res. Board Can. 29:639-671.

Behnke, R.J. 1979. Monograph of the native trouts of the genus Salmo of Western North America. Published jointly by U.S. Forest Service, Fish and Wildlife Service, and Bureau of Land Management. 163 p.

Biette, R.M., D.P. Dodge, R.L. Hassinger, and T.M. Stauffer. 1981. Life history and timing of migrations and spawning behavior of rainbow trout (Salmo gairdneri) populations of the Great Lakes. Can. J. Fish. Aquat. Sci. 38:1759-1771.

Blackith, R.E., and R.A. Reyment. 1971. Multivariate morphometrics. Academic Press, London. 412 p.

Burner, C.J. 1951, Characteristics of spawning nests of Columbia River salmon. Fishery Bull. No. 61, 50 p.

Carl, L.M. , and M.C. Healy. 1984. Differences in enzyme frequency and body morphology among three juvenile life history types of chinook salmon (Oncorhynchus tshawytscha) in the Nanaimo Ever, British Columbia. Can. J. Fish. Aquat. Sci. 41:107O-1077,

Casselman, J.M., J.J. Collins, E.J. Crossman, P.E. Ihssen, and G.R. Spangler, 1981, Lake whitefish (Coregonus clupeaformis) stocks of the Ontario waters of Lake Huron. Can. J. Fish. Aquat. Sci. 38:1772-1789,

Chilcote, M.W., B.A. Crawford, and S.A. Leider. 1980, A genetic comparison of sympatric populations of summer and winter steelheads, Trans. Am. Fish, SOC. 109:203-206.

Cleaver, F. 1968. Survivals of inter-hatchery transfers of fall chinook Salmon, Proceedings 1968 Northwest Fish Cultural Conference, Boise, ID. p. 34-36.

Clifford, H.T., and W. Stephenson, 1975, An introduction to numerical classification. Academic Press, New York, NY. 229 p.

Cochran, W.G. 1954. Some methods for strengthening the common X^2 test. Biometrics 10:417-451.

Cooper, D.W. 1968. The significance level in multiple tests made Simultaneously. Heredity 23:614-617.

Donaldson, L.R. 1970. Selective breeding in salmonid fishes, pages 65-74. In: W.J. McNeil (ed.). Marine Aquaculture. Oregon State University Press, Corvallis.

Fulton, L.A. 1968, Spawning areas and abundance of chinook salmon (Oncorhynchus tshawytscha) in the Columbia River Basin--past and present. U.S. Fish Wildl. Serv. Spec. Sci. Rpt.-Fisheries No. 571. 26 p. + 6 maps,

Fulton, L.A. 1970. Spawning areas and abundance of steelhead trout and coho, sockeye and chum salmon in the Columbia Ever Basin-past and present l . U.S. Nat. Mar. Fish, Service Spec. Sci. Rpt.-Fisheries No. 618. 37 P. + maps.

Gall, G.A.E. 1972. Phenotypic and genetic components of body size and spawning performance, pages 159-163. In: R.W. Moore (ed.). Progress in Fishery and Food Science. Univ. Washington Publications in Fisheries, New Series, Vol. 5, Univ. Washington, Seattle.

Garrison, R.C., and N.M. Rosentreter. 1981. Stock assessment and genetic studies of anadromous salmonids. Federal Aid Progress Rpts. Fisheries, 1980, Portland: Oregon Dept. Fish & Wildlife, Fish Div. 66 p.

Hartl, D. 1981. A Primer of Population Genetics. Sinauer Assoc., Inc. Sanderland, MA. 191 p.

Highsmith, R.M., Jr. (ed.). 1973. Atlas of the Pacific Northwest. Oregon State Univ. Press, Corvallis. 128 p.

Hjort, R.C., and C.B. Schreck. 1982. Phenotypic differences among stocks of hatchery and wild coho salmon (Oncorhynchus kisutch) in Oregon, Washington, and California, Fish. Bull. 80:105-119.

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, N. Kendra, and D. Ortman. 1985a. Final Report: Stock assessment of Columbia River anadromous salmonids, Vol. I: coho, chum, sockeye salmon stock summaries - stock transfer guidelines - information needs, U.S. Dept. Energy, Bonneville Power Admin. Div. Fish & Wildlife, Portland, OR.

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, W. Kendra, and D. Ortman. 1985b. Final Report: Stock assessment of Columbia River anadromous salmonids. Vol. II: steelhead stock summaries - stock transfer guidelines - information needs. U.S. Dept. Energy, Bonneville Power Admin., Div. Fish & Wildlife, Portland, OR.

Hubbs, C.L., and L.C. Hubbs. 1945. Bilateral asymmetry and bilateral variation in fishes. Papers Michigan Academy Sci. 30:239-310.

Huxley, J.S. 1932, Problems of relative growth. Dial, New York. 276 p.

Ihssen, P.E. 1976. Selective breeding and hybridization in fisheries management. J. Fish. Res. Board Can. 33:316-321.

Ihssen, P.E., H.E. Booke, J.M. Casselmann, J.M. McGlade, N.R. Payne, and F.M. Utter. 1981a. Stock identification: materials and methods. Can. J. Fish. Aquat. Sci. 38:1838-1855.

Ihssen, P.E., D.O. Evans, W.J. Christie, J.A. Reckahn, and R.C. DesJardine, 1981b. Life history, morphology, and electrophoretic characteristics of five allopatric stocks of lake whitefish (Coregonus clupeaformis) in the Great Lakes Region, Can. J. Fish, Aquat. Sci. 38:1790-1807.

Jordan, D.S. 1894. Latitude and vertebrae: A study in the evolution of fishes, Pop. SCi. Monthly 45:346-350.

Kimura, M. 1968. Evolutionary rate at the molecular level. Nature 217:624-626, Kimura, M., and T. Maruyama. 1971, Patterns of neutral polymorphism in a geographically structured population. Genet. Res. 125:131.

Larkin, P.A. 1972. The stock concept and management of Pacific salmon. Pages 11-18. In R.D. Simon and P.A. Larkin (ed.). The stock concept of Pacific salmon. H.R. MacMillan Lecture Series in Fisheries. Univ. British Columbia, Vancouver, BC.

Larkin, P.A. 1981. A perspective on population, genetics and salmon management. Can. J. Fish. Aquat. Sci. 38:1469-1475.

Lindsey, C.C., A.M. Brett, D.P. Swan, and A.N. Arnason, 1984. Responses of vertebral numbers in rainbow trout to temperature changes during development. Can. J. Zool. 62:391-396.

Loch, J.S. 1974. Phenotypic variation in the lake whitefish (Coregonus clupeaformis), Induced by introduction into a new environment. J. Fish, Res. Board Can. 31:55-62.

Loftus, K.H. 1976. Science for Canada's fisheries rehabilitation needs. J. Fish. Res. Board Can. 33:1822-1857.

Loy, W.G., S. Allan, C.P. Patton, and R.D. Plank. 1976. Atlas of Oregon. Univ. Oregon, Eugene. 215 p.

MacGregor, R.B., and H.R. MacCrimmon. 1977. Evidence of genetic and environmental influences on meristic variation in the rainbow trout, Salmo gairdneri Richardson. Env. Biol. Fish. 2:25-33.

Martin, W.R. 1949. The mechanics of environmental control of body form in fishes, Univ, Toronto, Stud,, Biol. Ser. No. 58; Publ. Ontario Fish, Research Lab., No. 70. 91 p.

Mayr, E. 1971. Populations, species and evolution. Belknap Press, Harvard Univ. Press, Cambridge, MA. 453 p.

McDonald, J. 1981, The stock concept and its application to British Columbia fisheries. Can. J. Fish. Aquat. Sci. 38:1657-1664.

, Milner, G.B., D.J. Teel, and F.M. Utter. 1983. Columbia River stock Identification study. Prepared for USDE Bonneville Power Admin., Portland, OR, and USPCI NOM Natl. Marine Fish, Serv., Seattle, WA. 33 p. + Appendix.

Milner, G.B., D. J. Teel, and F.M. Utter. 1980. Columbia River stock identification study. Final report of research. U.S. Fish Wildl. Serv. and Natl. Marine Fish, Serv. 28 p. + Appendix.

Misra, R.K., and I.H. Ni. 1983, Distinguishing beaked redfishes (deepwater redfish, Sebastes mentella and Labrador redfish (z. fasciatus by discriminate analysis (with covariance) and multivariate analysis of covariance. Can. J. Fish. Aquat. SCi. 40:1507-1511.

Neave, F. 1944, Racial characteristics and migratory habits in Salmo gairdneri. J. Fish, Res. Board Can. 6:245-251.

Nei, M. 1972. Genetic distance between populations. Am. Nat. 106:283-292.

Northcote, T.G., and B.W. Kelso. 1981. Differential response to water current by two homezygons LDH phenotypes of young rainbow trout (Salmo gairdneri). Can. J. Fish. Aquat. Sci. 38:348-352.

Parkinson, E.A. 1984. Genetic variation in populations of steelhead trout (Salmo gairdneri) in British Columbia. Can. J. Fish. Aquat. Sci. 41:1412-1420.

Radcliffe, L. 1928. Need for racial studies on fishes. Copeia 169:85-88.

Reisenbichler, R.R., and J.D. McIntyre. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout Salmo gairdneri. J. Fish. Res. Board Can. 34:123-128.

Ricker, W.E. 1972. Hereditary and environmental factors affecting certain salmonid populations, p. 19-160. In: R.D. Simon and P.A. Larkin (eds.). The stock concept of Pacific salmon. H.R. MacMillan lectures in fisheries. Univ. British Columbia, Vancouver, BC.

Riddell, B.E., and W.C. Leggett. 1981. Evidence of an adaptive basis for geographical variation in body morphology and time of downstream migration of juvenile Atlantic salmon (Salmo salar). Can. J. Fish. Aquat. Sci. 38:308-320.

Riddell, B.E., W.C. Leggett, and R.L. Saunders. 1981. Evidence of adaptive polygenic variation between two populations of Atlantic salmon (Salmo salar) native to tributaries of the S.W. Miramich River, New Brunswick, Canada. Can. J. Fish. Aquat. Sci. 38:321-333.

Romanov, N.S. 1984. Effects of culture conditions on skull morphology in smolts of the masu salmon (Oncorhynchus masou). Aquaculture 41:147-153.

Royal, L.A. 1953. The effects of regulatory selectivity on the productivity of Fraser River sockeye. Can. Fish. Cult. 14:1-12.

Ryman, N., and G. Stahls. 1981. Genetic perspectives of the identification and conservation of Scandinavian stocks of fish. Can. J. Fish. Aquat. sci. 38: 1562-1575.

Saunders, R.L. 1981. Atlantic salmon (Salmo salar) stocks and management implications in the Canadian Atlantic Provinces and New England, USA. Can. J. Fish. Aquat. Sci. 38:1612-1625.

Schaffer, W.M., and P.F. Elson. 1975. The adaptive significance of variations in life history among local populations of Atlantic salmon in North America. Ecology 56:577-590.

Seymour, A. 1959. Effects of temperature upon the formation of vertebrae and fin rays in young chinook salmon. Trans. Am. Fish. Soc. 88:58-69.

Smith, S.B. 1969. Reproductive isolation in summer and winter races of steelhead trout. Pages 21-38. In: T.G. Northcote (ed.). Symposium on salmon and trout in streams. H.R. MacMillan Lectures in Fisheries. Univ. of British Columbia, Vancouver, British Columbia, Canada.

Sneath, P.H.A., and R.R. Sokol. 1973. Numerical taxonomy, the principles and practices of numerical classification. W.H. Freeman, San Francisco. 573 p.

Snedecor, G.W., and W.G. Cochran. 1967. Statistical methods. 6th ed. Iowa State Univ. Press, Ames. 593 p.

Stihl, G. 1983. Differences in the amount and distribution of genetic variation between natural and hatchery stocks of Atlantic salmon. Aquaculture 33:23-32.

Suzumoto, B.K., C.B. Schreck, and J.D. McIntyre. 1977. Relative resistance of three transferrin genotypes of coho salmon (Oncorhynchus kisutch) and their hematological responses to bacterial kidney disease. J. Fish. Res. Board Can. 34:1-8.

Tåning , A.V. 1952. Experimental study of meristic characters in fishes. Biol. Rev. Cambridge Philos. Soc. 27:169-193.

Taylor, E.B., and J.D. McPhail. 1985a. Variation in burst and prolonged swimming performance among British Columbia populations of coho salmon, Oncorhynchus kisutch. Can. J. Fish. Aquat. Sci. 42:2029-2033.

Taylor, E.B., and J.D. McPhail. 1985b. Variation in body morphology among British Columbia populations of coho salmon (Oncorhynchus kisutch). Can. J. Fish. Aquat. Sci. 42:2020-2028,

Thorpe, J.E. 1980. Ocean ranching-general considerations. p. 152-154, In: Atlantic salmon: its future. Proc. 2nd Int'l. Atlantic Salmon Symp.

Thorpe, J.E., and J.F. Koonce (with D. Borgeson, B. Henderson, A. Lamsa, P.S. Maitland, M.A. Ross, R.C. Simon, and C. Walters). 1981. Assessing and managing man's impact on fish genetic resources. Can. J. Fish. Aquat. Sci, 38:1899-1907,

Tsuyukl, H., and S.N. Williscroft. 1977. Swimming stamina differences between genetypically distinct forms of rainbow (Salmo gairdneri) and steelhead trout. J. Fish. Res. Board Can. 34:996-1003.

Utter, F.M. 1981. Biological criteria for definition of species and distinct intraspecific populations of anadromous salmonids under the U.S. Endangered Species Act of 1973. Can. J. Fish. Aquat. Sci. 38:1626-1635.

Utter, F.M., H.O. Hodgins, and F.W. Allendorf. 1974. Biochemical genetic studies of fishes: potentialities and limitations, p. 213-238. In: D.C. Malins and J.R. Sargent (eds.). Biochemical and biophysical perspectives in marine biology. Vol. I. Academic Press, Inc., San Francisco, CA.

Vernon, E.H. 1957. Morphometric comparison of three races of kokanee (Oncorhynchus nerka) within a large British Columbia lake. J. Fish. Res. Board Can. 14:573-598.

Warren, C.E., and W.J. Liss. 1980. Adaptation to aquatic environments, p. 15-40. In: R.T. Lackey and L.A. Nielsen (eds.). Fisheries Management. John Wiley and Sons, Inc., New York, NY.

Winans, G.A. 1984. Multvariate morphometric variability in Pacific salmon: technical demonstration. Can. J. Fish. Aquat. Sci, 41:1150-1159.

Winter, G.W., C.B. Schreck, and J.D. McIntyre. 1980. Meristic comparison of four stocks of steelhead trout (Salmo gairdneri). Copeia 1980(l): 160-162.

Withler, I.L. 1966. Variability in life history characteristics of steelhead trout (Salmo gairdneri) along the Pacific coast of North America. J. Fish. Res. Board Can. 23:365-393.

APPENDICES

APPENDIX TABLE A1

Isozyme gene frequencies and sample sizes (N) as determined by electrophoresis for chinook salmon stocks in Oregon, Washington and Idaho. Numbers at the top of each column are the relative mobilities for each allele present in the enzyme system. Minus signs indicate cathodal migration. An asterisk indicates that an allele was present at a frequency of less than .005. "Form" is the time of freshwater entry (S for spring, F for fall and SUM for summer). A pound sign (#) indicates that data for that stock was obtained from the Genetic Stock Identification Study (Milner et al. 1983).

Table Al. Chinook salmon gene frequency data.

CHINOOK STOCK	FORM	ACONITATE HYDRATASE					ADENOSINE DEAMINASE			ALCOHOL DEHYDROGENASE		
		N	100	86	116	69	N	100	83	N	-100	-52
COWLITZ HATCHERY #	F	91	.82	.17	.02		98	.99	.01	49	.97	.03
COWLITZ HATCHERY	S	92	.83	.16	.01					95	.96	.04
KALAMA HATCHERY	F	91	.91	.08	.01		-			88	.88	.12
KALAMA HATCHERY	S	96	.85	.14	.01					100	.96	.04
LEWIS HATCHERY	S	100	.98	.02			84	.92	.08	100	.98	.02
LEWIS HATCHERY	F	75	.77	.23						61	.94	.06
LEWIS RIVER	F	82	.82	.16	.01					194	.97	.03
CLACKAMAS RIVER	F	47	.69	.30	.01		50	1.00		50	.99	.01
CLACKAMAS RIVER	S	79	.77	.20	.03					80	.99	.01
EAGLE CREEK HATCHERY	S	87	.76	.21	.03		100	1.00		100	.98	.02
EAGLE CREEK HATCHERY 85	S	95	.79	.17	.03	.01	60	1.00		100	.99	.01
MARION FORKS HATCHERY	S	97	.79	.19	.02		100	1.00		100	1.00	
SOUTH SANTIAM HATCHERY	S	98	.72	.27	.01		65	1.00		100	1.00	
THOMAS CREEK	S	95	.83	.16	.01					100	.98	.02
MCKENZIE HATCHERY	S	98	.79	.19	.02		50	1.00		100	1000	
MCKENZIE HATCHERY 85	S	95	.85	.13	.02	.01	95	1.00		100	1.00	
DEXTER HATCHERY	S	98	.75	.22	.03		100	1.00		100	1.00	
SANDY RIVER	F	56	.94	.03	.03					56	1.00	
SANDY RIVER 85	F	48	.88	.09	.03		49	1.00		49	.96	.04
WASHOUGAL RIVER	F	50	.86	.13	.01		50	.99	.01	50	.95	.05
BONNEVILLE HATCHERY	F	93	1.00				93	1.00		87	.87	.13
CARSON HATCHERY	S	100	.98	.02						100	1.00	
CARSON HATCHERY 85	S	100	.99	.01			75	.97	.03	97	.95	.05
LIT.WHITE SALMON HATCH.	S	100	.98	.02						100	1.00	
LIT.WHITE SALMON HATCH. 85	S	98	.99	.01			88	.99	.01	98	.99	.01
SPRING CREEK HATCHERY	F	100	1.00				100	1.00		82	.85	.15
KLICKITAT RIVER	F	50	.76	.23	.01		50	.99	.01	50	.96	.04
KLICKITAT HATCHERY #	S	50	.93	.07			50	.98	.02	-		
HOOD RIVER	F	42	.88	.12								
DESCHUTES RIVER	F	85	.87	.06	.07					87	.93	.07
DESCHUTES RIVER 85	F	52	.83	.14	.03		54	.98	.02	53	.84	.16
ROUND BUTTE HATCHERY	S	93	1.00				78	1.00		83	1.00	
ROUND BUTTE HATCHERY 85	S	98	.99		.01		50	1.00		98	1.00	
WARM SPRINGS RIVER #	S	50	,1.00				50	1.00		50	1.00	
JOHN DAY RIVER	S	78	1.00				76	.99	.01	78	.99	.01
JOHN DAY RIVER 85	S	60	.98	.02			60	1.00		60	1.00	
SNAKE RIVER STOCK	F	97	.93	.06	.01					97	.91	.09
TUCANNON RIVER	S	93	.99	.01						93	1.00	
TUCANNON RIVER 85	S	34	.97	.03			38	.97	.03	28	1.00	
GRANDE RONDE RIVER	S	43	.98	.02			43	1.00		43	1.00	
GRANDE RONDE RIVER 84	S	26	.98	.02						36	.99	.01

Table A1. Chinook salmon gene frequency data (continued).

CHINOOK STOCK	FORM		ACONITATE HYDRATASE				ADENOSINE DEAMINASE			ALCOHOL DEHYDROGENASE		
		N	100	86	116	69	N	100	83	N	-100	-52
WALLOWA-LOSTINE RIVER	S	47	1.00				47	1.00		47	1.00	
WALLOWA-LOSTINE RIVER 84	S	40	.99	.01						40	.98	.03
KOOSKIA HATCHERY STOCK	S	100	1.00							90	.99	.01
RED R. SF CLEARWATER #	S	40	1.00				40	.98	.03	40	1.00	
IMNAHA RIVER	S	87	.99	.01			87	1.00		87	.99	.01
IMNAHA RIVER 84	S	108	.99	.01						108	1.00	
RAPID RIVER HATCHERY #	S	50	.98	.02			50	.98	.02	50	1.00	
JOHNSON CREEK #	SUM	53	1.00				56	1.00		56	1.00	
McCALL HATCHERY #	SUM	50	1.00				50	.90	.10	50	1.00	
MIDDLE FORK SALMON	S	50	.98	.02						86	1.00	
EAST FK. SALMON R. STOCK	S	50	1.00				50	.98	.02	50	1.00	
VALLEY CREEK	SUM	20	1.00							50	1.00	
VALLEY CREEK #	S	22	1.00				22	.93	.07	22	1.00	
SAWTOOTH STOCK #	S	50	1.00				48	.97	.03	50	1.00	
YAKIMA RIVER	F	36	.97	.03			36	.97	.03	36	.99	.01
YAKIMA RIVER	S	50	.98	.02			42	.96	.04	50	1.00	
NACHES RIVER	S	37	1.00				50	1.00		50	.98	.02
HANFORD REACH	F	53	.89	.11						100	1.00	
HANFORD REACH 85	F	100	.81	.18	.01		100	1.00		100	.97	.04
PRIEST RAPIDS HATCHERY	F	100	.84	.16			50	1.00		100	.99	.01
WENATCHEE RIVER	S	194	.99	.01			50	.95	.05	199	1.00	
WENATCHEE RIVER	SUM	40	.81	.19						50	1.00	
WENATCHEE RIVER 85	SUM	49	.83	.17			50	.99	.01	50	1.00	
LEAVENWORTH HATCHERY	S	89	.99	.01						100	1.00	
LEAVENWORTH HATCHERY 85	S	100	1.00				100	.97	.04	100	1.00	
ENTIAT RIVER	S	128	.98	.02			50	.97	.03	133	1.00	
WELLS DAM HATCHERY	SUM	98	.88	.12			98	1.00		100	1.00	
METHOW RIVER 83	S	53	.97	.03								
METHOW RIVER 84	S	50	.99	.01			50	.96	.04	50	1.00	
METHOW RIVER	SUM	85	.82	.18								
WINTHROP HATCHERY #	S	50	.92	.07	.01		129	.97	.03	129	.98	.02
OKANAGAN RIVER	SUM	100	.78	.22						90	.97	.03
OKANAGAN RIVER 85	SUM	50	.75	.24	.01		50	1.00		49	.99	.01

Table Al. Chinook salmongene frequencydata (continued).

CHINOOK STOCK	FORM	GLUCOSE PHOSPHATE ISOMERASE-2 N	100	60	GLUCOSE PHOSPHATE ISOMERASE 1-3H N	STANDARD	VARIANT	GLUCOSE PHOSPHATE ISOMERASE-3 N	100	90
COWLITZ HATCHERY #	F	99	1.00					99	1.00	
COWLITZ HATCHERY	S	100	1000		100	.90	.10	100	1.00	
KALAMA HATCHERY	F	100	1.00		100	1.00		100	1.00	
KALAMA HATCHERY	S	100	1.00		100	.86	.14	100	1.00	
LEWIS HATCHERY	S	100	1.00		100	1.00		100	1.00	
LEWIS HATCHERY	F	96	.90	.10	96	1.00		100	1.00	
LEWIS RIVER	F	100	1.00		100	1.00		100	1.00	
CLACKAMAS RIVER	F	50	1.00		50	1.00		50	1.00	
CLACKAMAS RIVER	S	80	1.00		80	1.00		80	1.00	
EAGLE CREEK HATCHERY	S	100	1.00		100	1.00		100	1.00	
EAGLE CREEK HATCHERY 85	S	100	1.00		100	1.00		100	1.00	
MARION FORKS HATCHERY	S	100	1.00		100	1.00		100	1.00	
SOUTH SANTIAM HATCHERY	S	100	1.00		100	1.00		100	1.00	
THOMAS CREEK	S	100	1.00		100	.80	.20	100	1.00	
MCKENZIE HATCHERY	S	95	1.00		95	.90	.10	95	1.00	
MCKENZIE HATCHERY 85	S	100	1.00		100	1.00		100	1.00	
DEXTER HATCHERY	S	100	1.00		100	.83	.17	100	1.00	
SANDY RIVER	F	66	1.00		66	1.00		66	1.00	
SANDY RIVER 85	F	49	.96	.04	49	100		49	1.00	
WASHOUGAL RIVER	F	50	.80	.20	50	1.00		50	1.00	
BONNEVILLE HATCHERY	F	93	1.00		93	1.00		93	1.00	
CARSON HATCHERY	S	100	1.00		100	1.00		100	1.00	
CARSON HATCHERY 85	S	95	1.00		95	1.00		95	1.00	
LIT.WHITE SALMON HATCH.	S	50	1.00		50	1.00		50	1.00	
LIT.WHITE SALMON HATCH. 85	S	98	.90	.10	98	1.00		98	1.00	
SPRING CREEK HATCHERY	F	100	1.00		100	1.00		100	1.00	
KLICKITAT RIVER	F	50	1.00		50	1.00		50	1.00	
KLICKITAT HATCHERY #	S	50	1.00					50	1.00	
HOOD RIVER	F	47	.99	.01	47	1.00		47	.99	.01
DESCHUTES RIVER	F	91	1.00		91	1.00		91	1.00	
DESCHUTES RIVER 85	F	51	1.00		51	.94	.06	51	.98	.02
ROUND BUTTE HATCHERY	S	100	1.00		100	1.00		100	1.00	
ROUND BUTTE HATCHERY 85	S	98	1.00		98	1.00		98	1.00	
WARM SPRINGS RIVER #	S	49	1.00					49	1.00	
JOHN DAY RIVER	S	79	1.00		79	1.00		79	1.00	
JOHN DAY RIVER 85	S	60	1.00		60	1.00		60	1.00	
SNAKE RIVER STOCK	F	100	.90	.10	100	1.00		100	1.00	
TUCANNON RIVER	S	100	.86	.14	100	1.00		100	1.00	
TUCANNON RIVER 85	S	44	1.00		44	1.00		44	1.00	
GRANDE RONDE RIVER	S	43	1.00		43	1.00		43	1.00	
GRANDE RONDE RIVER 84	S	36	1.00		36	1.00		36	1.00	

Table Al. Chinook salmon gene frequency data (continued).

CHINOOK STOCK	FORM	GLUCOSE PHOSPHATE ISOMERASE-2			GLUCOSE PHOSPHATE ISOMERASE 1-3H			GLUCOSE PHOSPHATE ISOMERASE-3		
		N	100	60	N	STANDARD	VARIANT	N	100	90
WALLOWA-LOSTINE RIVER	S	47	.90	.10	47	1.00		47	1.00	
WALLOWA-LOSTINE RIVER 84	S	40	1.00		40	1.00		40	1.00	
KOOSKIA HATCHERY STOCK	S	78	1.00		78	1.00		78	1.00	
RED R. SF CLEARWATER #	S	40	1.00					40	1.00	
IMNAHA RIVER	S	87	1.00		87	1.00		87	1.00	
IMNAHA RIVER 84	S	108	1.00		100	1.00		100	1.00	
RAPID RIVER HATCHERY #	S	50	1.00					50	1.00	
JOHNSON CREEK #	SUM	56	1.00					56	1.00	
McCALL HATCHERY #	SUM	50	1.00					50	1.00	
MIDDLE FORK SALMON	S	50	1.00		50	1.00		50	1.00	
EAST FK. SALMON R. STOCK	S	50	1.00		50	1.00		50	1.00	
VALLEY CREEK	SUM	48	1.00		48	1.00		48	1.00	
VALLEY CREEK #	S	22	1.00					22	1.00	
SAWTOOTH STOCK #	S	50	1.00					50	1.00	
YAKIMA RIVER	F	36	1.00		36	1.00		36	1.00	
YAKIMA RIVER	S	42	1.00		30	1.00		48	100	
NACHES RIVER	S	50	.94	.06	50	1.00		50	1.00	
HANFORD REACH	F	96	1.00		96	.80	.20	96	1.00	
HANFORD REACH 85	F	100	1.00		100	.90	.10	100	1.00	
PRIEST RAPIDS HATCHERY	F	91	1.00		91	.90	.10	91	1.00	
WENATCHEE RIVER	S	194	1.00		194	1.00		194	1.00	
WENATCHEE RIVER	SUM	50	1.00		50	1.00		50	1.00	
WENATCHEE RIVER 85	SUM	50	1.00		50	.96	.04	50	1.00	
LEAVENWORTH HATCHERY	S	95	1.00		95	1.00		95	1.00	
LEAVENWORTH HATCHERY 85	S	93	1.00		93	1.00		93	1.00	
ENTIAT RIVER	S	133	1.00		133	1.00		133	1.00	
WELLS DAM HATCHERY	SUM	97	1.00		97	.83	.17	97	1.00	
METHOW RIVER 83	S	53	1.00		53	1.00		53	1.00	
METHOW RIVER 84	S	50	1.00		40	1.00		50	1.00	
METHOW RIVER	SUM	88	1.00		88	.89	.11	88	1.00	
WINTHROP HATCHERY #	S	129	1.00					129	.98	.02
OKANAGAN RIVER	SUM	100	.90	10	100	.83	.17	100	1.00	
OKANAGAN RIVER 85	SUM	50	1.00		50	1.00		50	1.00	

Table Al. Chinook salmon gene frequencydata (continued),

CHINOOK STOCK	FORM	ASPARTATE AMINOTRANSFERASE			ISOCITRATE DEHYDROGENASE				L-LACTATE DEHYDROGENASE-4		
		N	100	90	N	100	74	127	N	100	120
COWLITZ HATCHERY #	F	68	1.00		97	.97	.02	.01	99	1.00	
COWLITZ HATCHERY	S	100	1.00		100	.97	.03		100	1.00	
KALAMA HATCHERY	F	100	1.00		73	.98	.01	.01	100	1.00	
KALAMA HATCHERY	S	100	1.00		88	.93	.07		100	1.00	
LEWIS HATCHERY	S	68	1.00		95	.87	.13		100	1.00	
LEWIS HATCHERY	F	194	1.00		87	.96	.01	.03	98	1.00	
LEWIS RIVER	F	100	1.00		99	.97	.01	.02	100	1.00	
CLACKAMAS RIVER	F	50	1.00		50	.91		.09	50	.99	.01
CLACKAMAS RIVER	S	80	1.00		76	.95	.01	.04	80	1.00	
EAGLE CREEK HATCHERY	S	90	1.00		100	1.00			100	1.00	
EAGLE CREEK HATCHERY 85	S	90	1.00		94	.91		.09	100	1.00	
MARION FORKS HATCHERY	S	100	1.00		100	1.00			100	1.00	
SOUTH SANTIAM HATCHERY	S	90	1.00		100	1.00			100	1.00	
THOMAS CREEK	S	100	1.00		89	.88	.11	.01	100	1.00	
MCKENZIE HATCHERY	S	100	1.00		70	.98	.01	*	100	1.00	
MCKENZIE HATCHERY 85	S	50	1.00		97	.87	.02	.11	100	1.00	
DEXTER HATCHERY	S	100	1.00		100	1.00			85	1000	
SANDY RIVER	F	66	1.00		56	.96	.02	.01	66	1.00	
SANDY RIVER 85	F	49	1.00		49	.96		.04	47	1.00	
WASHOUGAL RIVER	F	50	1.00		48	.95	.02	.03	50	1.00	
BONNEVILLE HATCHERY	F	93	1.00						93	1.00	
CARSON HATCHERY	S	100	1.00		87	.97	.03		100	.98	.02
CARSON HATCHERY 85	S	52	1.00		83	.90	.09	.01	100	1.00	
LIT.WHITE SALMON HATCH.	S	100	1.00						100	.98	.02
LIT.WHITE SALMON HATCH. 85	S	38	1.00		87	.92	.08		98	1.00	
SPRING CREEK HATCHERY	F	100	1.00		100	1.00			100	1.00	
KLICKITAT RIVER	F	50	1.00		50	.91	.02	.07	50	1.00	
KLICKITAT HATCHERY #	S	49	1.00		50	.90	.03	.07	50	1.00	
HOOD RIVER	F				41	.99	.01		47	1.00	
DESCHUTES RIVER	F	96	1.00		98	.98	.01	*	100	1.00	
DESCHUTES RIVER 85	F	52	1.00		54	.98	.01	.02	54	1.00	
ROUND BUTTE HATCHERY	S	50	1.00		82	.95	.05	*	93	1.00	
ROUND BUTTE HATCHERY 85	S	42	1.00		97	.86	.14		98	1.00	
WARM SPRINGS RIVER #	S	43	1.00		50	.83	.17		50	1.00	
JOHN DAY RIVER	S	75	1.00		70	.87	.13		95	1.00	
JOHN DAY RIVER 85	S	60	1.00		60	.94	.06	*	59	1.00	
SNAKE RIVER STOCK	F	100	.98	.02	88	.99	.01		100	1.00	
TUCANNON RIVER	S	100	l.00		92	.95	.05		100	.99	.01
TUCANNON RIVER 85	S	50	1.00		34	.94	.03		50	1.00	
GRANDE RONDE RIVER	S	43	1.00		42	.92	.08		43	1.00	
GRANDE RONDE RIVER 84	S	8	1.00		34	.87	.13		36	1.00	

Table Al. Chinook salmon gene frequency data (continued).

CHINOOK STOCK	FORM	ASPARTATE AMINOTRANSFERASE			ISOCITRATE DEHYDROGENASE				L-LACTATE DEHYDROGENASE-4		
		N	100	90	N	100	74	127	N	100	120
WALLOWA-LOSTINE RIVER	S	25	1.00		46	.86	.11	.03	47	1.00	
WALLOWA-LOSTINE RIVER 84	S	34	1.00		35	.84	.15	.01	40	1.00	
KOOSKIA HATCHERY STOCK	S	80	1.00		73	.92	.08		100	.99	.01
RED R. SF CLEARWATER #	S	40	1.00		80	.94	.06		40	.95	.05
IMNAHA RIVER	S	87	1.00		84	.91	.09		87	1.00	
IMNAHA RIVER 84	S	100	1.00		89	.87	.13		108	1.00	
RAPID RIVER HATCHERY #	S	50	1.00		50	.97	.04		50	.98	.02
JOHNSON CREEK #	SUM	56	1.00		56	.95	.05		56	1.00	
McCALL HATCHERY #	SUM	50	1.00		50	.87	.13		50	1.00	
MIDDLE FORK SALMON	S	40	1.00		14	.89	.11		50	.96	.04
EAST FK. SALMON R. STOCK	S	37	1.00		50	.97	.03		50	.99	.01
VALLEY CREEK	SUM	45	1.00		40	.98	.02		48	.98	.02
VALLEY CREEK #	S	22	1.00		22	.91	.05	.05	22	.98	.02
SAWTOOTH STOCK #	S	50	1.00		50	.92	.08		50	.98	.02
YAKIMA RIVER	F	36	1.00		30	.91	.03	.06	36	.97	.03
YAKIMA RIVER	S	44	1.00		44	.86	.14		50	1.00	
NACHES RIVER	S	50	1.00		50	.95	.04	.01	50	1.00	
HANFORD REACH	F	100	1.00		60	.92	.01	.07	100	1.00	
HANFORD REACH 85	F	100	1.00		91	.93	.06	.01	100	1.00	
PRIEST RAPIDS HATCHERY	F				65	.98,	.02		92	1.00	
WENATCHEE RIVER	S	180	1.00		160	.86	.14		199	.99	.01
WENATCHEE RIVER	SUM				44	.98	.01	.01	50	1.00	
WENATCHEE RIVER 85	SUM	50	1.00		50	.89	.01	.10	50	1.00	
LEAVENWORTH HATCHERY	S				96	.90	*	.10	100	.97	.03
LEAVENWORTH HATCHERY 85	S	75	1.00		94	.93	.07		100	1.00	
ENTIAT RIVER	S	123	1.00		105	.81	.19		132	.98	.02
WELLS DAM HATCHERY	SUM								98	100	
METHOW RIVER 83	S	50	1.00		39	.89	.02	.09	43	1.00	
METHOW RIVER 84	S	43	1.00		37	.81	.19		50	.99	.01
METHOW RIVER	SUM	20	1.00		71	.95	.04	*			
WINTHROP HATCHERY #	S	50	1.00		129	.97	.03	.01	129	1.00	
OKANAGAN RIVER	SUM				84	.93	.06	.01	96	1.00	
OKANAGAN RIVER 85	SUM	50	1.00		50	.92		.08	50	1.00	

Table Al. Chinook salmon gene frequencydata (continued).

CHINOOK STOCK	FORM	L-LACTATE DEHYDROGENASE-5 N	100	90	MALATE DEHYDROGENASE-1&2 N	100	140	27	MALATE DEHYDROGENASE-3&4 N	100	121	70
COWLITZ HATCHERY #	F	96	.99	.01	99	1.00			99	1.00		
COWLITZ HATCHERY	S	100	.99	.01	100	1.00			100	.99	.01	
KALAMA HATCHERY	F	100	1.00		100	1.00			100	.98	.02	
KALAMA HATCHERY	S	100	.99	.01	100	1.00			100	.99	001	
LEWIS HATCHERY	S	80	1.00		50	1.00			100	.98	.02	
LEWIS HATCHERY	F	98	1.00		100	1.00			90	.99	.01	
LEWIS RIVER	F	100	1.00		100	1.00			94	.98	.02	
CLACKAMAS RIVER	F	50	.99	.01	50	1.00			50	.93	.07	
CLACKAMAS RIVER	S	87	1.00		80	1.00			80	.97	.03	
EAGLE CREEK HATCHERY	S	87	1.00		100	1.00			100	.95	.05	
EAGLE CREEK HATCHERY 85	S	100	.99	.01	100	1.00			100	.97	.03	
MARION FORKS HATCHERY	S	100	1.00		100	1.00			98	.92	.08	
SOUTH SANTIAM HATCHERY	S	100	1.00		94	1.00			100	.95	.05	
THOMAS CREEK	S	100	1.00		100	1.00			99	.92	.08	
MCKENZIE HATCHERY	S	100	.99	.01	100	1.00			99	.93	.07	
MCKENZIE HATCHERY 85	S	100	1.00		100	1.00			97	.94	.06	
DEXTER HATCHERY	S	85	1.00		100	1.00			100	.93	.07	
SANDY RIVER	F	66	1.00		66	1.00			66	1.00		
SANDY RIVER 85	F	47	.99	.01	49	1.00			49	.98	.02	
WASHOUGAL RIVER	F	50	1.00		50	1.00			50	.97	.03	
BONNEVILLE HATCHERY	F	83	1.00		93	1.00			88	.92	.08	
CARSON HATCHERY	S	100	1.00		100	1.00			100	1.00	*	
CARSON HATCHERY 85	S	85	1.00		100	1.00			100	.99	.01	
LIT.WHITE SALMON HATCH.	S	92	1.00		100	1.00			100	.98	.02	
LIT.WHITE SALMON HATCH. 85	S	89	1.00		98	1.00			96	.94	.06	
SPRING CREEK HATCHERY	F	100	1.00		100	1.00			100	092	.08	
KLICKITAT RIVER	F	50	.96	.04	50	1.00			50	.99	.01	
KLICKITAT HATCHERY #	S	50	1.00		50	1.00			50	097	.03	
HOOD RIVER	F	47	1.00		47	1.00			47	.99		.01
DESCHUTES RIVER	F	100	1.00		100	1.00			100	097	.01	.02
DESCHUTES RIVER 85	F	53	.99	.01	54	1.00			54	.96	.01	.02
ROUND BUTTE HATCHERY	S	93	1.00		93	1.00			100	.99	.01	
ROUND BUTTE HATCHERY 85	S	83	1.00		98	1.00			98	.98	.02	
WARM SPRINGS RIVER #	S	46	1.00		50	.99	.01		49	1.00		
JOHN DAY RIVER	S	96	1.00		100	.99	.01		100	1.00		
JOHN DAY RIVER 85	S	59	1.00		60	1.00			60	.96	.04	
SNAKE RIVER STOCK	F	100	.99	.01	100	1.00			100	.95	.01	.04
TUCANNON RIVER	S	100	1.00		100	1.00			100	1.00		
TUCANNON RIVER 85	S	29	.94	.06					50	1.00		
GRANDE RONDE RIVER	S	43	1.00		43	1.00			43	1.00		
GRANDE RONDE RIVER 84	S				36	1.00			36	.98	.02	

Table Al. Chinook salmon gene frequency data (continued).

CHINOOK STOCK	FORM	L-LACTATE DEHYDROGENASE-5			MALATE DEHYDROGENASE-1&2				MALATE DEHYDROGENASE-3&4			
		N	100	90	N	100	140	27	N	100	121	70
WALLOWA-LOSTINE RIVER	S	47	1.00		47	1.00			45	.95	.05	
WALLOWA-LOSTINE RIVER 84	S	40	1.00		40	1.00			40	1.00		
KOOSKIA HATCHERY STOCK	S	100	1.00		90	1.00			100	.98	.02	
RED R. SF CLEARWATER #	S	40	1.00		80	1.00			78	.99	.01	
IMNAHA RIVER	S	87	1.00		87	1.00			87	.99	.01	
IMNAHA RIVER 84	S	107	1.00		108	1.00			108	.98	.02	
RAPID RIVER HATCHERY #	S	50	1.00		50	1.00			49	1.00		
JOHNSON CREEK #	SUM	56	.98	.02	56	100			56	1.00		
McCALL HATCHERY #	SUM	50	.97	.03	50	1.00			50	.99	.01	
MIDDLE FORK SALMON	S	50	1.00						50	.98	.02	
EAST FK. SALMON R. STOCK	S	37	1.00		50	1.00			50	.98	.02	
VALLEY CREEK	SUM	48	l.oo		45	1.00			48	.97	.03	
VALLEY CREEK #	S	22	1.00		22	1.00			22	.99	.01	
SAWTOOTH STOCK #	S	48	1.00		50	1.00			49	1.00		
YAKIMA RIVER	F	36	1.00		36	1.00			36	100		
YAKIMA RIVER	S	50	1.00		50	1.00			50	1.00		
NACHES RIVER	S	50	1.00		50	1.00			50	.98	.01	.01
HANFORD REACH	F	100	.97	.03	100	100			98	.97	.01	.01
HANFORD REACH 85	F	100	.99	.01	100	100			100	.96	.03	.01
PRIEST RAPIDS HATCHERY	F	100	.98	.02	100	1.00			100	.98	.01	.02
WENATCHEE RIVER	S	181	1.00		195	1.00	*		95	.97	.03	
WENATCHEE RIVER	SUM	45	.99	.01	50	1.00			48	.97	.01	.02
WENATCHEE RIVER 85	SUM	50	.96	.04	50	100			50	.95	.01	.04
LEAVENWORTH HATCHERY	S	100	100		100	l.00			100	.99	.01	
LEAVENWORTH HATCHERY 85	S	97	1.00		95	1.00			99	.97	.03	
ENTIAT RIVER	S	121	1.00		132	1.00	*		31	.99	.01	
WELLS DAM HATCHERY	SUM	90	.99	.01	98	1.00			98	.98	.01	.01
METHOW RIVER 83	S	50	.99	.01	43	1.00			45	.97	.03	
METHOW RIVER 84	S	49	1.00		50	.99	*	*	50	.97	.03	
METHOW RIVER	SUM	80	.99	.01	88	1.00			87	.97	.02	.01
WINTHROP HATCHERY #	S	129	100		129	100			129	.99	.01	
OKANAGAN RIVER	SUM	100	.93	.07	100	1.00			95	.97	.02	.01
OKANAGAN RIVER 85	SUM	50	.95	.05	50	100			50	.96	.02	.02

Table Al. Chinook salmon gene frequency data (continued).

CHINOOK STOCK	FORM	MANNOSE PHOSPHATE ISOMERASE					DIPEPTIDASE			TRIPEPTIDE AMINOPEPTIDASE			
		N	100	109	95	113	N	100	90	N	100	130	45
COWLITZ HATCHERY #	F	99	.49	.48	.03		99	.92	.08	99	.94	.06	
COWLITZ HATCHERY	S	99	.47	.50	.03		100	.99	.01	100	.91	.39	
KALAMA HATCHERY	F	56	.63	.37			100	100		100	.70	.30	
KALAMA HATCHERY	S	100	.57	.43			100	1.00		100	.95	.05	
LEWIS HATCHERY	S	72	.85	.15			100	.98	.02	95	.95	.05	
LEWIS HATCHERY	F	85	.53	.45	.02		98	.95	.05	95	.93	.07	
LEWIS RIVER	F	100	.49	.48	.03		100	.84	.16	100	.96	.04	
CLACKAMAS RIVER	F	49	.45	.55			50	.97	.03	49	.94	.06	
CLACKAMAS RIVER	S	79	.47	.53			80	100		80	.96	.04	
EAGLE CREEK HATCHERY	S	84	.61	.38		.01	100	1.00		99	.92	.08	
EAGLE CREEK HATCHERY 85	S	69	.41	.59			100	100		91	.90	.09	.01
MARION FORKS HATCHERY	S	95	.46	.54			100	100		98	091	.09	
SOUTH SANTIAM HATCHERY	S	97	.50	.50			100	1.00		95	.65	.35	
THOMAS CREEK	S	95	.42	.58			100	l.oo		100	087	.13	
MCKENZIE HATCHERY	S	97	.47	.52	.01		100	l.oo		99	.87	.13	
MCKENZIE HATCHERY 85	S	96	.52	.48			96	1.00					
DEXTER HATCHERY	S	88	.53	.47			100	100		100	.83	.17	
SANDY RIVER	F	64	.55	.44	.01		66	100		66	.95	.05	
SANDY RIVER 85	F	49	.50	.49	.01		49	.99	.01	49	.93	.07	
WASHOUGAL RIVER	F	49	.50	.48	.02		50	.85	.15	50	.96	.04	
BONNEVILLE HATCHERY	F	87	.59	.40	.01		93	1.00		92	.83	.17	
CARSON HATCHERY	S	99	.90	.10			100	1.00		100	.91	.09	
CARSON HATCHERY 85	S	97	.89	.11			95	1.00		80	.96	.04	
LIT.WHITE SALMON HATCH.	S	96	.82	.18			100	.99	.01	99	.94	.06	
LIT.WHITE SALMON HATCH. 85	S	80	.79	.21			71	1.00		93	.05	.05	
SPRING CREEK HATCHERY	F	96	.54	.43	.03		100	.94	.06	96	.83	.17	
KLICKITAT RIVER	F	50	.68	.31	.01		50	.95	.05	49	.81	.19	
KLICKITAT HATCHERY #	S	50	.73	.26	.01		50	.99	.01	50	.95	.05	
HOOD RIVER	F	-					47	100		47	.93	.07	
DESCHUTES RIVER	F	99	.79	.21			100	.97	.03	99	.97	.03	
DESCHUTES RIVER 85	F	53	.79	.21			54	.92	.08	52	.96	.04	
ROUND BUTTE HATCHERY	S	93	.84	.16			93	100		93	.98	.02	
ROUND BUTTE HATCHERY 85	S	-					98	1.00		77	.96	.04	
WARM SPRINGS RIVER #	S	50	.84	.16			50	6.97	.03	48	.97	.03	
JOHN DAY RIVER	S	93	.91	.09			100	1.00		85	.99	.01	
JOHN DAY RIVER 85	S	55	.88	.12			60	.99	.01	60	.99	.01	
SNAKE RIVER STOCK	F	100	.82	.18			100	.99	.01	86	.87	.13	
TUCANNON RIVER	S	100	.90	.10			100	100		90	.99	.01	
TUCANNON RIVER 85	S	49	.90	.10			50	100		38	.99	.01	
GRANDE RONDE RIVER	S	36	.92	.08			43	100		43	.98		.02
GRANDE RONDE RIVER 84	S	36	.90	.10			36	.99	.01	35	.96	.04	

Table Al. Chinook salmon gene frequency data (continued).

CHINOOK STOCK	FORM	MANNOSE PHOSPHATE ISOMERASE N	100	109	95	113	DIPEPTIDASE N	100	90	TRIPEPTIDE AMINOPEPTIDASE N	100	130	45
WALLOWA-LOSTINE RIVER	S	45	.76	.24			47	1.00		43	.96	.04	
WALLOWA-LOSTINE RIVER 84	S	39	.74	.26			35	1.00		40	.99	.01	
KOOSKIA HATCHERY STOCK	S	74	.95	.05			91	.98	.02	71	.99	.01	
RED R. SF CLEARWATER #	S	40	.95	.05			40	1.00		36	.94	.06	
IMNAHA RIVER	S	86	.80	.20			87	.99	.01	87	.99	.01	.01
IMNAHA RIVER 84	S	99	.82	.18			108	1.00		108	100		
RAPID RIVER HATCHERY #	S	50	.95	.05			50	1.00		50	.90	.10	
JOHNSON CREEK #	SUM	56	.95	.05			56	1.00		56	.99	.01	
McCALL HATCHERY #	SUM	50	.96	.04			50	1.00		50	.93	.07	
MIDDLE FORK SALMON	S	50	.96	.04			50	1.00		37	.97	.03	
EAST FK. SALMON R. STOCK	S	50	1.00				50	1.00		50	1.00		
VALLEY CREEK	SUM	35	.87	.13			45	1.00		32	1.00		
VALLEY CREEK #	S	22	.80	.21			22	.98	.02	22	.82	.18	
SAWTOOTH STOCK #	S	50	.89	.11			50	.99	.01	50	.86	.14	
YAKIMA RIVER	F	36	.92	.08			36	100		35	.84	.16	
YAKIMA RIVER	S	50	.86	.14			50	.98	.02	47	.95	.05	
NACHES RIVER	S	46	.77	.23			50	1.00		49	.98	.02	
HANFORD REACH	F	99	.72	.27	.01		100	100		100	.77	.23	
HANFORD REACH 85	F	99	.54	.46			100	.99	.01	99	.82	.18	
PRIEST RAPIDS HATCHERY	F	88	.74	.26			100	1.00		94	.68	.32	
WENATCHEE RIVER	S	165	.90	.10			191	.99	.01	181	.91	.09	
WENATCHEE RIVER	SUM	34	.66	.34			50	1.00					
WENATCHEE RIVER 85	SUM	50	.63	.37			50	.94	.06	50	.74	.26	
LEAVENWORTH HATCHERY	S	100	.90	.10			100	.99	.01	100	.87	.13	
LEAVENWORTH HATCHERY 85	S	93	.83	.17			100	.99	.01	90	1.00		
ENTIAT RIVER	S	132	.90	.10			132	.99	.01	118	.94	.06	
WELLS DAM HATCHERY	SUM	76	.71	.29			98	1.00		98	.66	.34	
METHOW RIVER 83	S	36	.85	.15			53	1.00		53	.90	.10	
METHOW RIVER 84	S	50	.97	.03			50	1.00		50	.97	.03	
METHOW RIVER	SUM	-					88	1.00		86	.73	.27	
WINTHROP HATCHERY #	S	22	.70	.30			22	1.00		22	.99	.01	
OKANAGAN RIVER	SUM	92	.74	.26			100	1.00		96	.68	.32	
OKANAGAN RIVER 85	SUM	50	.63	.37			50	.99		48	.69	.31	

Table Al. Chinook salmon gene frequency data (continued).

CHINOOK STOCK	FORM	PHOSPHO-GLUCOMUTASE N	-100	-60	PHOSPHOGLYCERATE KINASE-2 N	100	90	64	SUPEROXIDE DISMUTASE N	-100	-260	1250
COWLITZ HATCHERY #	F	99	.99	.01	50	.79	.21		98	.65	.35	
COWLITZ HATCHERY	S	100	1.00						99	.57	.43	
KALAMA HATCHERY	F	100	1.00		52	.88	.12		80	.58	.42	
KALAMA HATCHERY	S	100	1.00						100	.66	.34	
LEWIS HATCHERY	S	100	1.00		100	.14	.86		50	.56	.44	
LEWIS HATCHERY	F	100	1.00						47	.48	.52	
LEWIS RIVER	F	100	1.00						194	.56	.44	
CLACKAMAS RIVER	F	49	1.00		49	.86	.14		49	.86	.14	
CLACKAMAS RIVER	S	80	1.00						28	.84	.16	
EAGLE CREEK HATCHERY	S	100	1.00		95	.06	.94		98	.67	.33	
EAGLE CREEK HATCHERY 85	S	100	1.00		91	.97	.03		99	.74	.26	
MARION FORKS HATCHERY	S	50	1.00		77	.98	.02		100	.80	.20	
SOUTH SANTIAM HATCHERY	S	100	1.00		99	.94	.06		99	.84	.16	
THOMAS CREEK	S	100	1.00		100	.93	.07		100	.81	.19	
MCKENZIE HATCHERY	S	100	1.00		84	.88	.12		100	.81	.19	
MCKENZIE HATCHERY 85	S	100	1.00		60	.88	.12		98	.79	.21	
DEXTER HATCHERY	S	100	1.00		94	.90	.10		100	.92	.08	
SANDY RIVER	F	66	1.00									
SANDY RIVER 85	F	49	1.00		49	.82	.18		49	.56	.44	
WASHOUGAL RIVER	F	50	.96	.04	42	.71	.29		50	.48	.52	
BONNEVILLE HATCHERY	F	93	1.00		93	1.00			83	.52	.48	
CARSON HATCHERY	S	100	1.00		100	.02	.98		97	.81	.19	
CARSON HATCHERY 85	S	100	1.00		96	.12	.88		93	.77	.23	
LIT.WHITE SALMON HATCH.	S	100	1.00		72	.12	.88		100	.78	.22	
LIT.WHITE SALMON HATCH. 85	S	98	1.00		98	.09	.91		92	.85	.15	
SPRING CREEK HATCHERY	F	100	1.00		91	.91	.09		80	.58	.42	
KLICKITAT RIVER	F	50	1.00		50	.61	.39		45	.54	.46	
KLICKITAT HATCHERY #	S	50	1.00		50	.57	.43		50	.69	.31	
HOOD RIVER	F	47	1.00									
DESCHUTES RIVER	F	100	1.00						76	.70	.30	
DESCHUTES RIVER 85	F	54	1.00		53	.52	.48		52	.63	.38	
ROUND BUTTE HATCHERY	S	93	1.00		93	.45	.55		81	.56	.44	
ROUND BUTTE HATCHERY 85	S	98	1.00		80	.18	.82		95	.65	.35	
WARM SPRINGS RIVER #	S	50	1.00		50	.32	.68		50	.54	.46	
JOHN DAY RIVER	S	95	1.00		39	.06	.94		81	.73	.27	
JOHN DAY RIVER 85	S	60	100		60	.28	.72		60	.70	.30	
SNAKE RIVER STOCK	F	100	1.00		51	.67	.33		88	.64	.36	
TUCANNON RIVER	S	93	1.00		77	.06	.94		54	.78	.22	
TUCANNON RIVER 85	S	50	1.00		27	.02	.98		40	.86	.14	
GRANDE RONDE RIVER	S	43	1.00		37	.23	.77		43	.79	.21	
GRANDE RONDE RIVER 84	S	36	1.00						36	.85	.15	

Table Al. Chinook salmon gene frequency data (continued).

CHINOOK STOCK	FORM	PHOSPHO-GLUCOMUTASE			PHOSPHOGLYCERATE KINASE-2				SUPEROXIDE DISMUTASE			
		N	-100	-60	N	100	90	64	N	-100	-260	1250
WALLOWA-LOSTINE RIVER	S	47	1.00		45	.07	.92	.01	47	.79	.21	
WALLOWA-LOSTINE RIVER 84	S	40	100		90		1.00		40	.86	.14	
KOOSKIA HATCHERY STOCK	S	100	1.00		46	.04	.96		99	.84	.16	
RED R. SF CLEARWATER #	S	40	1.00		40	.15	.85		40	095	.05	
IMNAHA RIVER	S	87	1.00		78	.15	.85		87	.89	.11	
IMNAHA RIVER 84	S	108	1.00		90		1.00		87	.87	.13	
RAPID RIVER HATCHERY #	S	50	1.00		50	.15	.85		50	.96	.04	
JOHNSON CREEK #	SUM	56	1.00		56	.05	.96		56	.97	.03	
MCCALL HATCHERY #	SUM	50	1.00		50	.08	.92		50	.98	.02	
MIDDLE FORK SALMON	S	50	1.00		50	.05	.95		35	.80	.20	
EAST FK. SALMON R. STOCK	S	50	1.00						50	.98	.02	
VALLEY CREEK	SUM	48	1.00		43	.20	.80		48	.94	.06	
VALLEY CREEK #	S	22	1.00		22	.21	.80		22	.89	.11	
SAWTOOTH STOCK #	S	50	1.00		50	.09	.91		48	.95	.05	
YAKIMA RIVER	F	36	1.00		36	.38	.62		36	.85	.15	
YAKIMA RIVER	S	50	1.00		30	.17	.83		50	.76	.24	
NACHES RIVER	S	49	1.00		50	.38	.62		49	.70	.30	
HANFORD REACH	F	100	1.00		39	.74	.26					
HANFORD REACH 85	F	100	1.00		100	.65	.36		100	.53	.47	
PRIEST RAPIDS HATCHERY	F	100	1.00						92	.50	.50	
WENATCHEE RIVER	S	184	1.00		76	.09	.91		170	.82	.18	*
WENATCHEE RIVER	SUM	50	1.00									
WENATCHEE RIVER 85	SUM	50	1.00		50	.58	.42		50	.46	.53	.01
LEAVENWORTH HATCHERY	S	100	100		76	.03	.97		100	.84	.16	
LEAVENWORTH HATCHERY 85	S	100	1.00		79	.12	.88		94	l 71	.29	
ENTIAT RIVER	S	128	100		35	.03	.97		130	.76	.24	
WELLS DAM HATCHERY	SUM	98	1.00		74	.64	.36		97	.58	.42	
METHOW RIVER 83	S	53	1.00						36	.67	.33	
METHOW RIVER 84	S	50	1.00		35	.03	.97		50	.77	.23	
METHOW RIVER	SUM	88	.99	.01	-				76	.49	.51	
WINTHROP HATCHERY #	S	123	1.00		98	.50	.50		129	.74	.26	
OKANAGAN RIVER	SUM	100	1.00		49	.70	.30					
OKANAGAN RIVER 85	SUM	50	1.00		50	.68	.32		50	.52	.48	

APPENDIX TABLE A2

Isozyme gene frequencies and sample sizes (N) as determined by electrophoresis for steelhead trout stocks in Oregon, Washington and Idaho. Numbers at the top of each column are the relative mobilities for each allele present in the enzyme system. Minus signs indicate cathodal migration. An asterisk indicates that an allele was present at a frequency of less than .005. "Form" is the time of freshwater entry (S for summer and W for winter). A pound sign (#) indicates that data for that stock was obtained from the Genetic Analysis of Columbia River Steelhead Trout (Wishard and Seeb 1983) prepared for the Idaho Department of Fish and Game.

Table A2. Steelhead trout gene frequency data.

STEELHEAD STOCK	FORM	ACONITATE HYDRATASE				ALCOHOL DEHYDROGENASE				GLYCEROL-3-PHOSPHATE DEHYDROGENASE		
		N	100	83	66	N	-100	-76	-82	N	100	140
BIG CREEK HATCHERY	W	98	.94	.06		100	1.00			100	.99	.01
BIG CREEK HATCHERY 85	W	95	.84	.10	.06	95	1.00			95	.99	.01
GRAYS RIVER	W	87	.81	.15	.04	100	1.00			100	.99	.01
ELOCHOMAN HATCHERY	W	49	.72	.18	.09	100	1.00			97	.97	.03
COWLITZ HATCHERY NATIVE	W	68	.91	.09		85	1.00			83	.91	.09
COWLITZ HATCHERY CHAMBERS	W	97	.86	.10	.04	100	1.00			92	.97	.03
COWLITZ HATCHERY SKAMANIA	S	87	.92	.07	.01	90	1.00			75	.95	.05
S.F. TOUTLE RIVER	W	50	.86	.12	.02	40	1.00			50	.93	.07
COWEEMAN RIVER	W	74	.86	.07	.07	74	1.00			74	.98	.02
EAGLE CREEK HATCH.(BIG CRK.)	W	100	.93	.04	.04	100	1.00			90	.97	.03
EAGLE CREEK HATCHERY 85	W	49	.88	.06	.06	50	1.00			50	.98	.02
EAGLE CREEK HATCH.(NATIVE)	W	80	.99	.01		100	1.00			51	.97	.03
EAGLE CREEK HATCHERY 85	W	96	.95	.05	.01	100	1.00			70	.96	.04
MARION FORKS HATCHERY	W	100	.99	.01		100	1.00			100	.85	.15
THOMAS CREEK 83	W	50	.98		.02	90	1.00					
THOMAS CREEK 84	W	55	.98		.02	55	1.00			40	.93	.07
THOMAS CREEK 85	W	24	.96	.04		48	1.00			48	1.00	
WILEY CREEK	W	100	.96	.02	.02	100	1.00			100	.74	.26
WILEY CREEK 85	W	27	.93	.06	.02	54	1.00			54	.83	.17
SOUTH SANTIAM HATCHERY	S	97	.98	.02		97	1.00			96	.93	.07
CALAPOOYA RIVER	W	-				80	1.00					
CALAPOOYA RIVER 84	W	45	1.00			45	1.00			44	.85	.15
LEABURG HATCHERY	S	100	.99	.01		100	1.00			97	.92	.08
LEABURG HATCHERY 85	S	50	.86	.14		50	1.00			50	.93	.07
MCKENZIE RIVER	S	50	.93	.07		50	1.00			50	.83	.17
SANDY RIVER	W	95	.87	.12	.01	100	1.00			100	.96	.04
WASHOUGAL HATCHERY	S	100	.95	.05		100	1.00			95	.77	.23
WASHOUGAL HATCHERY 85	S	97	.98	.01	.01	100	1.00			98	.94	.06
WASHOUGAL HATCHERY	W	100	.87	.05	.08	100	.99	.01		99	.99	.01
HAMILTON CREEK	W	52	.89	.12		53	1.00			53	.88	.12
WIND RIVER	S	38	.95	.05		50	1.00			35	.96	.04
WIND RIVER 85	S	25	.82	.18		25	1.00			25	.92	.08
HOOD RIVER	W	50	.89	.11		50	1.00			50	.97	.03
KLICKITAT RIVER	S	95	.89	.08	.02	100	1.00			85	.90	.10
FIFTEENMILE CREEK	W	81	.85	.10	.05	82	1.00					
FIFTEENMILE CREEK 85	W	50	.94	.06		50	1.00			50	.99	.01
DESCHUTES RIVER	S	139	.69	.31		178	1.00	*		178	.99	.01
ROUND BUTTE HATCHERY	S	92	.73	.27		100	.99	.01		100	.99	.01
ROUND BUTTE HATCHERY 85	S	100	.69	.28	.04	100	1.00			100	.99	.01
JOHN DAY RIVER	S	84	.84	.16		100	1.00			100	1.00	
JOHN DAY RIVER 85	S	50	.94	.06		50	.94	.06		50	.99	.01

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	ACONITATE HYDRATASE				ALCOHOL DEHYDROGENASE				GLYCEROL-3-PHOSPHATE DEHYDROGENASE		
		N	100	83	66	N	-100	-76	-82	N	100	140
UMATILLA RIVER	S	87	.72	.28		100	.99	.01		100	1.00	
UMATILLA HATCHERY	S	98	.90	.03	.07	100	.97	.03		100	.99	.01
WALLA WALLA RIVER	S	40	.61	.36	.03	40	1.00			40	1.00	
TOUCHET RIVER	S	50	.76	.20	.04	50	1.00			45	1.00	
TUCANNON RIVER	S	107	.85	.12	.03	113	1.00			113	1.00	
TUCANNON RIVER 85	S	50	.83	.16	.01	50	1.00			50	1.00	
GRANDE RONDE RIVER	S	43	.80	.19	.01	50	1.00			50	.98	.02
GRANDE RONDE RIVER 84	S	96	.85	.14	.01	110	1.00			100	.96	.04
WALLOWA-LOSTINE	S	71	.86	.14		73	.99	.01				
WALLOWA-LOSTINE 84	S	58	.87	.13		100	1.00			100	1.00	
WALLOWA HATCHERY	S	100	.78	.15	.08	100	1.00			98	1.00	
MISSION CREEK +	S	30	.85	.15		30	1.00			30	1.00	
BIG CANYON/COTTONWOOD CRKS.+	S	87	.73	.27	.01	88	1.00			88	1.00	
DWORSHAK HATCHERY +	S	72	.63	.37		73	1.00			73	.99	.01
SELWAY RIVER +	S	89	.59	.40	.01	98	1.00			98	1.00	
LOCHSA RIVER +	S	50	.72	.28		50	1.00			50	1.00	
IMNAHA RIVER	S	89	.78	.21	.01	96	1.00					
IMNAHA RIVER 84	S	57	.83	.16	.01	58	1.00			55	1.00	
IMNAHA HATCHERY	S	100	.79	.21	*	100	1.00			100	1.00	
SHEEP & BARGAMIN CRKS. +	S	120	.77	.20	.04	120	1.00			120	1.00	
S.F.SALMON (SECESH RIVER)	S	52	.62	.32	.07	61	1.00			61	1.00	
S.F.SALMON (JOHNSON CREEK)	S	48	.69	.20	.11	50	1.00			50	1.00	
CHAMBERLAIN CREEK +	S	97	.69	.25	.06	97	1.00			97	1.00	
HORSE CREEK +	S	50	.77	.22	.01	51	1.00			51	1.00	
MIDDLE FORK SALMON RIVER #	S	158	.73	.09	.18	277	1.00			158	1.00	
PAHSIMEROI 'B' STOCK	S	47	.55	.45		50	1.00			50	1.00	
SAWTOOTH 'A' STOCK	S	49	.62	.36	.02	50	1.00			50	1.00	
HELLS CANYON STOCK	S	100	.78	.21	.01	100	1.00			100	.99	.01
YAKIMA RIVER	S	42	.86	.14		48	1.00			43	.98	.02
YAKIMA RIVER 84	S	45	.69	.31		49	1.00			49	1.00	
WENATCHEE RIVER	S	94	.79	.18	.04	96	.98	.01	.01	96	.93	.07
ENTIAT RIVER	S	48	.77	.18	.05	50	1.00			50	1.00	
WELLS HATCHERY	S	79	.76	.24		81	1.00			81	1.00	
METHOW RIVER	S	54	.72	.27	.01	58	1.00			58	1.00	

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	CREATINE KINASE			GLUCOSE PHOSPHATE ISOMERASE-1				GLUCOSE PHOSPHATE ISOMERASE-2		
		N	100	70	N	100	130	25	N	100	120
BIG CREEK HATCHERY	W	100	1.00		100	1.00			100	1.00	
BIG CREEK HATCHERY 85	W	95	1.00		95	1.00			95	1.00	
GRAYS RIVER	W	100	1.00		100	1.00			100	1.00	
ELOCHOMAN HATCHERY	W	100	1.00		100	1.00			100	1.00	
COWLITZ HATCHERY NATIVE	W	99	1.00		91	1.00			91	1.00	
COWLITZ HATCHERY CHAMBERS	W	83	1.00		95	1.00			95	1.00	
COWLITZ HATCHERY SKAMANIA	S	80	1.00		90	1.00			90	1.00	
S.F. TOUTLE RIVER	W	50	1.00		50	1.00			50	1.00	
COWEEMAN RIVER	W	74	1.00		74	1.00			74	1.00	
EAGLE CREEK HATCH.(BIG CRK.)	W	100	1.00		98	1.00.			98	1.00	
EAGLE CREEK HATCHERY 85	W	50	1.00		50	1.00			50	1.00	
EAGLE CREEK HATCH.(NATIVE)	W	100	1.00		80	1.00			80	1.00	
EAGLE CREEK HATCHERY 85	W	86	1.00		88	1.00			88	1.00	
MARION FORKS HATCHERY	W	100	1.00		100	.86	.14		100	1.00	
THOMAS CREEK 83	W	-			100	1.00			100	1.00	
THOMAS CREEK 84	W	55	1.00		55	1.00			55	1.00	
THOMAS CREEK 85	W	24	1.00		24	1.00			24	1.00	
WILEY CREEK	W	100	1.00		100	1.00			100	1.00	
WILEY CREEK 85	W	27	1.00		27	1.00			27	1.00	
SOUTH SANTIAM HATCHERY	S	97	1.00		97	1.00			97	1.00	
CALAPOOYA RIVER	W	-			100	1.00			100	1.00	
CALAPOOYA RIVER 84	W	47	1.00		47	1.00			47	1.00	
LEABURG HATCHERY	S	100	1.00		95	1.00			95	1.00	
LEABURG HATCHERY 85	S	50	1.00		50	1.00			50	1.00	
MCKENZIE RIVER	S	50	1.00		48	1.00			48	1.00	
SANDY RIVER	W	100	1.00		100	1.00			100	1.00	
WASHOUGAL HATCHERY	S	100	1.00		95	1.00			95	1.00	
WASHOUGAL HATCHERY 85	S	100	1.00		100	1.00			100	1.00	
WASHOUGAL HATCHERY	W	99	1.00		100	1.00			100	1.00	
HAMILTON CREEK	W	53	1.00		53	.99		.01	53	1.00	
WIND RIVER	S	50	1.00		50	.91		.09	50	1.00	
WIND RIVER 85	S	25	1.00		25	.96		.04	25	1.00	
HOOD RIVER	W	50	1.00		50	1.00			50	1.00	
KLICKITAT RIVER	S	100	1.00		100	1.00			100	1.00	
FIFTEENMILE CREEK	W	82	1.00		82	1.00			82	.96	.04
FIFTEENMILE CREEK 85	W	50	1.00		50	1.00			48	.95	.05
DESCHUTES RIVER	S	170	1.00		170	1.00			178	1.00	
ROUND BUTTE HATCHERY	S	93	.96	.04	100	1.00			100	1.00	
ROUND BUTTE HATCHERY 85	S	100	.96	.04	100	1.00			100	1.00	
JOHN DAY RIVER	S	100	1.00	*	100	1.00			100	1.00	
JOHN DAY RIVER 85	S	50	.98	.02	50	1.00			50	1.00	

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	CREATINE KINASE			GLUCOSE PHOSPHATE ISOMERASE-1				GLUCOSE PHOSPHATE ISOMERASE-2		
		N	100	70	N	100	130	25	N	100	120
UMATILLA RIVER	S	100	1.00		100	1.00			100	1.00	
UMATILLA HATCHERY	S	100	1.00		100	1.00			100	1.00	
WALLA WALLA RIVER	S	40	1.00		40	1.00			40	1.00	
TOUCHET RIVER	S	50	1.00		50	1.00			50	1.00	
TUCANNON RIVER	S	113	.99	.01	113	1.00			113	1.00	
TUCANNON RIVER 85	S	50	.99	.01	50	1.00			50	1.00	
GRANDE RONDE RIVER	S	50	1.00		50	1.00			50	1.00	
GRANDE RONDE RIVER 84	S	110	1.00		110	1.00			110	1.00	
WALLOWA-LOSTINE	S	73	1.00		73	1.00			73	1.00	
WALLOWA-LOSTINE 84	S	62	1.00		62	1.00			62	1.00	
WALLOWA HATCHERY	S	100	.99	.01	100	1.00			100	1.00	
MISSION CREEK	S	30	1.00		30	1.00			30	1.00	
BIG CANYON/COTTONWOOD CRKS.	S	88	1.00		88	1.00			88	1.00	
DWORSHAK HATCHERY	S	73	1.00		73	1.00			73	1.00	
SELWAY RIVER	S	98	1.00		97	1.00			98	1.00	
LOCHSA RIVER	S	50	1.00		47	1.00			50	1.00	
IMNAHA RIVER	S	81	1.00		96	1.00			96	1.00	
IMNAHA RIVER 84	S	58	1.00		58	1.00			58	1.00	
IMNAHA HATCHERY	S	100	1.00		100	.90	.10		100	1.00	
SHEEP & BARGAMIN CRKS.	S	120	1.00		120	1.00			120	1.00	
S.F.SALMON (SECESH RIVER)	S	61	1.00		61	1.00			61	1.00	
S.F.SALMON (JOHNSON CREEK)	S	50	.99	.01	50	1.00			50	1.00	
CHAMBERLAIN CREEK	S	-			97	.99	.01				
HORSE CREEK	S	51	1.00		50	1.00			51	1.00	
MIDDLE FORK SALMON RIVER #	S	-			158	.97	.03		158	1.00	
PAHSIMEROI 'B' STOCK	S	50	1.00		50	1.00			50	1.00	
SAWTOOTH 'A' STOCK	S	50	1.00		50	1.00			50	1.00	
HELLS CANYON STOCK	S	100	1.00		100	1.00			100	1.00	
YAKIMA RIVER	S	48	.99	.01	48	1.00			48	1.00	
YAKIMA RIVER 84	S	49	.99	.01	49	1.00			49	1.00	
WENATCHEE RIVER	S	96	1.00		96	1.00			96	1.00	
ENTIAT RIVER	S	50	1.00		50	1.00			50	1.00	
WELLS HATCHERY	S	81	1.00		81	1.00			81	1.00	
METHOW RIVER	S	55	1.00		58	1.00			58	1.00	

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	GLUCOSE PHOSPHATE ISOMERASE-3 N	100	120	92	ASPARTATE AMINO-TRANSFERASE-1,2 N	100	112	ASPARTATE AMINO-TRANSFERASE-3 N	100	77
BIG CREEK HATCHERY	W	100	1.00						100	1.00	
BIG CREEK HATCHERY 85	W	95	1.00			85	1.00		89	1.00	
GRAYS RIVER	W	100	.99		.01				100	1.00	
ELOCHOMAN HATCHERY	W	100	.98		.02	100	1.00		100	1.00	
COWLITZ HATCHERY NATIVE	W	91	.96		.04	99	1.00		90	1.00	
COWLITZ HATCHERY CHAMBERS	W	95	.96		.04	80	1.00		100	1.00	
COWLITZ HATCHERY SKAMANIA	S	90	.98		.02	90	1.00		90	1.00	
S.F. TOUTLE RIVER	W	50	.96	.01	.03	50	1.00		50	1.00	
COWEEMAN RIVER	W	74	.89	.01	.10	74	1.00		74	1.00	
EAGLE CREEK HATCH.(BIG CRK.)	W	98	1.00			100	1.00		100	1.00	
EAGLE CREEK HATCHERY 85	W	50	1.00			50	1.00		50	1.00	
EAGLE CREEK HATCH.(NATIVE)	W	80	1.00			80	1.00				
EAGLE CREEK HATCHERY 85	W	88	1.00			92	1.00		95	1.00	
MARION FORKS HATCHERY	W	100	1.00						100	1.00	
THOMAS CREEK 83	W	100	1.00								
THOMAS CREEK 84	W	55	1.00						55	1.00	
THOMAS CREEK 85	W	24	1.00			24	1.00		24	1.00	
WILEY CREEK	W	100	1.00						100	1.00	
WILEY CREEK 85	W	27	1.00			27	1.00		27	1.00	
SOUTH SANTIAM HATCHERY	S	97	.95		.05	47	.94	.06	97	1.00	
CALAPOOYA RIVER	W	100	1.00								
CALAPOOYA RIVER 84	W	47	1.00			47	1.00		47	1.00	
LEABURG HATCHERY	S	95	.96		.04	100	.99	.01	100	1.00	
LEABURG HATCHERY 85	S	49	.92		.08	42	1.00		50	1.00	*
MCKENZIE RIVER	S	48	.93	.07		36	1.00		50	1.00	
SANDY RIVER	W	100	1.00			100	1.00		100	1.00	
WASHOUGAL HATCHERY	S	95	.92		.08	50	1.00		100	1.00	
WASHOUGAL HATCHERY 85	S	97	.94		.06	85	1.00		89	1.00	
WASHOUGAL HATCHERY	W	100	.99		.01	100	1.00		100	1.00	
HAMILTON CREEK	W	53	.98		.02				53	1.00	
WIND RIVER	S	50	.92		.08				50	1.00	
WIND RIVER 85	S	25	.94		.06	25	1.00		25	1.00	
HOOD RIVER	W	50	1.00			50	1.00		50	1.00	
KLICKITAT RIVER	S	100	.98	.02	*				100	1.00	
FIFTEENMILE CREEK	W	82	1.00								
FIFTEENMILE CREEK 85	W	50	1.00			45	1.00		37	1.00	
DESCHUTES RIVER	S	-				178	1.00		178	1.00	
ROUND BUTTE HATCHERY	S	100	.99		.01				100	1.00	
ROUND BUTTE HATCHERY 85	S	100	1.00			93	1.00		99	1.00	
JOHN DAY RIVER	S	100	1.00		*				78	1.00	
JOHN DAY RIVER 85	S	50	1.00			47	1.00		45	1.00	

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	GLUCOSE PHOSPHATE ISOMERASE-3				ASPARTATE AMINO-TRANSFERASE-1,2			ASPARTATE AMINO-TRANSFERASE-3		
		N	100	120	92	N	100	112	N	100	77
UMATILLA RIVER	S	100	1.00			100	1.00				
UMATILLA HATCHERY	S	100	1.00						100	.98	.02
WALLA WALLA RIVER	S	40	1.00			34	1.00		30	1.00	
TOUCHET RIVER	S	50	1.00			44	1.00		50	1.00	
TUCANNON RIVER	S	113	1.00			103	1.00		103	1.00	
TUCANNON RIVER 85	S	50	1.00			50	1.00		50	1.00	
GRANDE RONDE RIVER	S	50	1.00			50	1.00		50	1.00	
GRANDE RONDE RIVER 84	S	110	.99	.01		110	1.00		60	1.00	
WALLOWA-LOSTINE	S	73	1.00			36	1.00				
WALLOWA-LOSTINE 84	S	62	1.00						62	1.00	
WALLOWA HATCHERY	S	100	1.00			100	1.00		100	1.00	
MISSION CREEK	S	30	1.00						30	1.00	
BIG CANYON/COTTONWOOD CRKS.	S	88	1.00			-			88	1.00	
DWORSHAK HATCHERY	S	73	1.00						72	.91	.09
SELWAY RIVER	S	97	.99		.01	-			97	1.00	
LOCHSA RIVER	S	50	1.00						50	.99	.01
IMNAHA RIVER	S	96	1.00			86	1.00		96	1.00	
IMNAHA RIVER 84	S	58	1.00			58	1.00		58	1.00	
IMNAHA HATCHERY	S	100	1.00			100	1.00		83	1.00	
SHEEP & BARGAMIN CRKS.	S	120	.99		.01	-			116	1.00	
S.F.SALMON (SECESH RIVER)	S	61	.99	.01							
S.F.SALMON (JOHNSON CREEK)	S	50	1.00			50	1.00		50	.99	.01
CHAMBERLAIN CREEK	S	97	.99	.01							
HORSE CREEK	S	50	1.00			-			50	1.00	
MIDDLE FORK SALMON RIVER #	S	277	.99	.01							
PAHSIMEROI 'B' STOCK	S	50	1.00			50	1.00		47	1.00	
SAWTOOTH 'A' STOCK	S	50	1.00			50	.99	.01	50	1.00	
HELLS CANYON STOCK	S	95	.97	.03		75	.99	.01	94	1.00	
YAKIMA RIVER	S	48	1.00			48	1.00		48	1.00	
YAKIMA RIVER 84	S	49	1.00			49	1.00		49	.98	.02
WENATCHEE RIVER	S	96	.97	.03		96	1.00		96	1.00	
ENTIAT RIVER	S	50	1.00			50	1.00				
WELLS HATCHERY	S	81	.98	.01	.01	50	1.00		100	.99	.01
METHOW RIVER	S	58	.96	.04					58	1.00	

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	ISOCITRATE DEHYDROGENASE-3,4					LACTATE DEHYDROGENASE-4				MALATE DEHYDROGENASE-1,2				
		N	100	40	120	71	N	100	76	111	N	100	140	70	40
BIG CREEK HATCHERY	W	98	.70	.14	*	.16	100	.96	.04		100	1.00			
BIG CREEK HATCHERY 85	W	71	.64	.12	.01	.23	92	.95	.05		95	1.00			
GRAYS RIVER	W	94	.69	.12		.19	100	.80	.20		100	1.00			
ELOCHOMAN HATCHERY	W	89	.75	.13	.01	.11	99	.85	.15		100	.99		.01	
COWLITZ HATCHERY NATIVE	W	90	.68	.12	.01	.19	99	.90	.10		99	1.00			
COWLITZ HATCHERY CHAMBERS	W	100	.65	.16	.02	.17	100	.90	.10		100	.99		.01	
COWLITZ HATCHERY SKAMANIA	S	88	.66	.14	.01	.19	90	.88	.12		90	1.00			
S.F. TOUTLE RIVER	W	39	.61	.19	.02	.18	50	.80	.20		50	1.00			
COWEEMAN RIVER	W	72	.69	.16	*	.17	74	.87	.13		74	1.00			
EAGLE CREEK HATCH.(BIG CR.)	W	95	.64	.20	.06	.10	100	.92	.08		100	1.00			
EAGLE CREEK HATCHERY 85	W	47	.65	.12	.08	.15	50	.81	.17	.02	50	1.00			
EAGLE CREEK HATCH.(NATIVE)	S	94	.70	.12	.03	.15	80	.78	.22		70	1.00			
EAGLE CREEK HATCHERY 85	S	70	.61	.14	.06	.19	91	.91	.09		100	1.00			
MARION FORKS HATCHERY	W	94	.64	.13	.02	.21	100	.53	.47		100	1.00			
THOMAS CREEK 83	W	58	.72	.04		.24	100	.60	.40		50	.98		.02	
THOMAS CREEK 84	W	52	.73	.12		.15	55	.71	.29		55	.98		.02	
THOMAS CREEK 85	W	23	.62	.15		.23	24	.50	.50		24	1.00			
WILEY CREEK	W	-					100	.55	.45	.01	100	1.00			
WILEY CREEK 85	W	26	.62	.22		.16	27	.76	.24		27	.97		.03	
SOUTH SANTIAM HATCHERY	S	89	.70	.18	.02	.10	96	.80	.20		94	.99		.01	
CALAPOOYA RIVER	W	68	.74	.04	.01	.21	98	.41	.59		100	.99		.01	
CALAPOOYA RIVER 84	W	46	.71	.12		.17	47	.48	.52		47	1.00			
LEABURG HATCHERY	S	97	.62	.19	.05	.14	100	.88	.12		90	1.00			
LEABURG HATCHERY 85	S	50	.66	.15	.02	.18	50	.81	.19		50	1.00			
MCKENZIE RIVER	S	44	.71	.18	.01	.10	50	.70	.30		50	1.00			
SANDY RIVER	W	97	.74	.13		.13	100	.90	.10		100	1.00			
WASHOUGAL HATCHERY	S	95	.64	.21	*	.15	99	.80	.20		100	1.00			
WASHOUGAL HATCHERY 85	S	76	.65	.19	.01	.15	100	.80	.20		100	1.00			
WASHOUGAL HATCHERY	W	69	.68	.11	.03	.18	99	.91	.09		100	1.00			
HAMILTON CREEK	W	50	.72	.13		.16	53	.88	.12		53	.99		.01	
WIND RIVER	S	42	.66	.18		.16	50	.79	.20	.01	50	1.00		*	
WIND RIVER 85	S	24	.58	.32	.01	.08	25	.78	.22		25	1.00			
HOOD RIVER	W	43	.62	.18		.20	50	.91	.09		50	1.00			
KLICKITAT RIVER	S	92	.71	.13	.01	.15	100	.60	.40		100	1.00			
FIFTEENMILE CREEK	W	82	.68	.09	.01	.22	81	.65	.35		82	1.00			
FIFTEENMILE CREEK 85	W	50	.73	.08	.01	.19	50	.56	.44		50	1.00			
DESCHUTES RIVER	S	231	.69	.13	*	.18	266	.39	.61		267	1.00	*		
ROUND BUTTE HATCHERY	S	97	.68	.15		.17	100	.44	.56		100	1.00			
ROUND BUTTE HATCHERY 85	S	95	.60	.20	.01	.20	100	.42	.53	.06	100	.99	.01		
JOHN DAY RIVER	S	73	.71	.12	.01	.17	100	.30	.70		100	1.00	*		
JOHN DAY RIVER 85	S	47	.67	.13	.02	.18	50	.40	.60		50	1.00			

Table A2. Steelhead trout gene frequency data (continued>.

STEELHEAD STOCK	FORM	ISOCITRATE DEHYDROGENASE-3,4 N	100	40	120	71	LACTATE DEHYDROGENASE-4 N	100	76	111	MALATE DEHYDROGENASE-1,2 N	100	140	70	40
UMATILLA RIVER	S	98	.66	.19		.15	99	.42	.58		100	.99	.01		
UMATILLA HATCHERY	S	90	.66	.12		.22	100	.57	.43		100	1.00			
WALLA WALLA RIVER	S	40	.62	.16		.23	40	.36	.64		40	.99			.01
TOUCHET RIVER	S	49	.61	.17		.21	50	.45	.55		50	.99	.01		
TUCANNON RIVER	S	106	.64	.17		.19	112	.33	.67		113	1.00			
TUCANNON RIVER 85	S	49	.62	.19		.19	50	.29	.70	.01	50	.99	.02		
GRANDE RONDE RIVER	S	50	.70	.15		.14	49	.25	.75		50	.98	.02		
GRANDE RONDE RIVER 84	S	74	.72	.12		.17	109	.39	.61		110	1.00			
WALLOWA-LOSTINE	S	72	.75	.14		.12	73	.34	.66		73	.99		.01	
WALLOWA-LOSTINE 84	S	57	.71	.12	*	.17	62	.36	.64						
WALLOWA HATCHERY	S	92	.67	.16		.17	100	.24	.77		100	1.00			
MISSION CREEK +	S	30	.64	.13		.23	30	.42	.58		30	.99	.01		
BIG CANYON/COTTONWOOD CRKS.+	S	86	.58	.15		.28	88	.16	.84		88	.99	.01		
DWORSHAK HATCHERY +	S	71	.65	.22		.13	73	.23	.77		73	.99	.01		
SELWAY RIVER +	S	96	.62	.15		.24	98	.34	.66		98	1.00			
LOCHSA RIVER +	S	43	.68	.12		.20	50	.27	.73		50	.99	.01		
IMNAHA RIVER	S	96	.70	.14		.16	96	.29	.71		96	1.00			
IMNAHA RIVER 84	S	57	.72	.13		.15	58	.28	.72		58	1.00			
IMNAHA HATCHERY	S	87	.74	.08	*	.18	99	.39	.61		50	1.00			
SHEEP & BARGAMIN CRKS. +	S	94	.57	.18		.25	120	.29	.70	.02	120	1.00			
S.F.SALMON (SECESH RIVER)	S	56	.64	.24		.12	61	.25	.75		61	1.00	*		
S.F.SALMON (JOHNSON CREEK)	S	47	.57	.33	.01	.10	50	.28	.72		50	1.00			
CHAMBERLAIN CREEK +	S	97	.67	.15	.01	.18	97	.24	.73	.03	97	1.00			
HORSE CREEK +	S	40	.68	.07	.01	.24	50	.28	.72		50	1.00			
MIDDLE FORK SALMON RIVER #	S	158	.67	.15		.18	277	.33	.66	.01	277	1.00			
PAHSIMEROI 'B' STOCK	S	38	.68	.09	.01	.22	50	.29	.71		50	.99	.01		
SAWTOOTH 'A' STOCK	S	28	.73	.08	.02	.17	50	.43	.56	.01	50	1.00			
HELLS CANYON STOCK	S	67	.63	.19		.18	100	.21	.74	.06	100	1.00			
YAKIMA RIVER	S	46	.65	.15	.02	.18	48	.68	.32		48	1.00			
YAKIMA RIVER 84	S	46	.62	.16		.22	49	.61	.39		49	.99	.02		
WENATCHEE RIVER	S	73	.62	.21	.01	.17	95	.38	.61	.01	96	1.00			
ENTIAT RIVER	S	50	.60	.19	*	.21	50	.29	.69	.02	50	.99	.01		
WELLS HATCHERY	S	81	.66	.18		.16	81	.26	.74		81	.98	.02		
METHOW RIVER	S	53	.66	.14		.20	58	.29	.71		58	.99	.01		

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	MALATE DEHYDROGENASE-3,4 N	100	83	110	90	NADP+ MALATE DEHYDROGENASE N	100	85	MANNOSE PHOSPHATE ISOMERASE N	100	94	110
BIG CREEK HATCHERY	W	100	.92	.08			100	.80	.20	100	1.00		
BIG CREEK HATCHERY 85	W	92	.90	.10		*	67	.90	.01	95	1.00		
GRAYS RIVER	W	99	.88	.10	.01	.01	90	.83	.17	100	1.00		
ELOCHOMAN HATCHERY	W	94	.89	.08		.03	100	.95	.05	57	1.00		
COWLITZ HATCHERY NATIVE	W	86	.91	.09			77	.62	.38	99	1.00		
COWLITZ HATCHERY CHAMBERS	W	99	.93	.07			98	.84	.16	100	1.00		
COWLITZ HATCHERY SKAMANIA	S	88	.82	.17	.01		85	.78	.22	90	1.00		
S.F. TOUTLE RIVER	W	50	.88	.11		.02	50	.63	.37	50	1.00		
COWEEMAN RIVER	W	74	.87	.04		.09	74	.80	.20	74	1.00		
EAGLE CREEK HATCH. (BIG CR.)	W	100	.89	.11			98	.83	.17	100	1.00		
EAGLE CREEK HATCHERY 85	W	50	.86	.11	.04		45	.94	.06	50	1.00		
EAGLE CREEK HATCH. (NATIVE)	W	95	.85	.15		.01				90	1.00		
EAGLE CREEK HATCHERY 85	W	88	.84	.10	.06		63	.98	.02	100	1.00		
MARION FORKS HATCHERY	W	100	.96	.04			100	1.00		76	1.00		
THOMAS CREEK 83	W	97	.93	.07			80	1.00					
THOMAS CREEK 84	W	46	.93	.07			55	1.00		55	1.00		
THOMAS CREEK 85	W	24	.97	.03			24	1.00		24	1.00		
WILEY CREEK	W	97	.90	.10	*		100	1.00		100	1.00		
WILEY CREEK 85	W	26	.90	.01		.09	27	1.00		27	1.00		
SOUTH SANTIAM HATCHERY	S	95	.91	.07	.02		92	.96	.04	.			
CALAPOOYA RIVER	W	89	.99	.01						50	1.00		
CALAPOOYA RIVER 84	W	46	.96	.04			47	1.00		47	1.00		
LEABURG HATCHERY	S	100	.84	.13	.03		100	.96	.04	100	1.00		
LEABURG HATCHERY 85	S	50	.83	.15	.02	.01	50	.92	.08	50	1.00		
MCKENZIE RIVER	S	50	.87	.12		.01	50	.96	.04	50	1.00		
SANDY RIVER	W	98	.92	.08	*		95	.88	.12	100	1.00		
WASHOUGAL HATCHERY	S	94	.82	.18			92	.82	.18	-			
WASHOUGAL HATCHERY 85	S	100	.91	.09			100	.96	.04	95	1.00		
WASHOUGAL HATCHERY	W	100	.88	.12			100	1.00		100	1.00		
HAMILTON CREEK	W	51	.89	.06	.04	.01	53	.89	.11	53	1.00		
WIND RIVER	S	49	.96	.04			50	.84	.16	50	1.00		
WIND RIVER 85	S	25	.97			.03	25	.83	.17	25	1.00		
HOOD RIVER	W	50	.91	.09	.01		50	.94	.06	50	1.00		
KLICKITAT RIVER	S	91	.91	.06	.02	.01	100	1.00		100	1.00		
FIFTEENMILE CREEK	W	82	.97	.01	.02		50	.94	.06	-			
FIFTEENMILE CREEK 85	W	50	.96	.03	.01		50	1.00		45	.99	.01	
DESCHUTES RIVER	S	267	.96	.04	*	*	267	1.00					
ROUND BUTTE HATCHERY	S	98	.96	.04	*		100	1.00		100	1.00		
ROUND BUTTE HATCHERY 85	S	100	.99	.01			98	1.00		100	.98	.01	.02
JOHN DAY RIVER	S	100	.99	*	*	*	50	1.00		100	1.00		
JOHN DAY RIVER 85	S	50	.99	.01	.01		50	.99	.01	50	.99	.01	

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	MALATE DEHYDROGENASE-3,4					NADP+ MALATE DEHYDROGENASE			MANNOSE PHOSPHATE ISOMERASE			
		N	100	83	110	90	N	100	85	N	100	94	110
UMATILLA RIVER	S	100	.98	*	.02		100	1.00		100	1.00		
UMATILLA HATCHERY	S	100	.98	.01	.01		100	1.00		50	1.00		
WALLA WALLA RIVER	S	40	.98	.02			40	1.00		30	.99	.01	
TOUCHET RIVER	S	50	.97	.01	.01	.02	50	1.00		50	.99	.01	
TUCANNON RIVER	S	112	.98	.01	.01		113	1.00					
TUCANNON RIVER 85	S	50	.99	.01			50	1.00		50	.96	.03	.01
GRANDE RONDE RIVER	S	50	.99	.01			50	1.00					
GRANDE RONDE RIVER 84	S	110	.99	*		.01	110	1.00		50	1.00		
WALLOWA-LOSTINE	S	73	.95	.01	.04		73	1.00		73	.99	.01	
WALLOWA-LOSTINE 84	S	62	.95	.01	.04	.01	62	1.00		62	1.00		
WALLOWA HATCHERY	S	100	.96	.01	.03		100	1.00		100	1.00		
MISSION CREEK	S	30	1.00							30	.95	.05	
BIG CANYON/COTTONWOOD CRKS.	S	88	1.00							88	.90	.10	
DWORSHAK HATCHERY	S	73	.99		.01					73	1.00		
SELWAY RIVER	S	98	1.00		*					98	.95	.04	.01
LOCHSA RIVER	S	50	.99		.01					40	1.00		
IMNAHA RIVER	S	96	1.00				94	1.00		96	.98	.01	.01
IMNAHA RIVER 84	S	58	1.00				58	1.00		58	1.00		
IMNAHA HATCHERY	S	100	1.00				100	1.00		100	1.00		
SHEEP & BARGAMIN CRKS.	S	120	.99		.02					120	.99	.02	
S.F.SALMON (SECESH RIVER)	S	61	.98		.02		61	1.00		61	1.00		
S.F.SALMON (JOHNSON CREEK)	S	50	.99	.01			50	1.00		50	.99	.01	
CHAMBERLAIN CREEK	S	97	.98		.01	.01				97	.98	.02	
HORSE CREEK	S	50	.99		.01	.01				50	1.00		
MIDDLE FORK SALMON RIVER #	S	277	.98	.02						277	1.00		
PAHSIMEROI 'B' STOCK	S	50	1.00				50	1.00		50	1.00		
SAWTOOTH 'A' STOCK	S	50	.99	.01			50	1.00		50	.95	.05	
HELLS CANYON STOCK	S	100	.98	.02			96	1.00		100	.99	.01	
YAKIMA RIVER	S	48	.98	.02	.01		48	1.00		48	1.00		
YAKIMA RIVER 84	S	49	1.00				49	1.00		49	1.00		
WENATCHEE RIVER	S	96	.94	.02		.04	96	1.00		96	.99		.01
ENTIAT RIVER	S	50	.99	*	*		40	1.00		50	1.00		
WELLS HATCHERY	S	76	.99		.01		76	1.00		81	1.00		
METHOW RIVER	S	58	.98	.01	.01		58	1.00		58	.99	.01	

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	DIPEPTIDASE N	100	110	85	95	TRIPEPTIDE AMINOPEPTIDASE N	100	129	74	50	PHOSPHO-GLUCOMUTASE-1 N	-100	-115	-85
BIG CREEK HATCHERY	W	100	1.00				100	1.00				100	1.00		
BIG CREEK HATCHERY 85	W	95	1.00				95	1.00				95	.99		.01
GRAYS RIVER	W	100	.99	.01			100	1.00				100	1.00		
ELOCHOMAN HATCHERY	W	99	1.00				90	1.00				100	1.00		
COWLITZ HATCHERY NATIVE	W	99	1.00				99	1.00				99	1.00		
COWLITZ HATCHERY CHAMBERS	W	100	1.00				100	1.00				100	1.00		
COWLITZ HATCHERY SKAMANIA	S	90	1.00				90	1.00				90	1.00		
S.F. TOUTLE RIVER	W	50	1.00				50	.99		.01		50	1.00		
COWEEMAN RIVER	W	74	1.00				73	.99	.01			74	1.00		
EAGLE CREEK HATCH. (BIG CR.)	W	100	1.00				100	1.00				100	1.00		
EAGLE CREEK HATCHERY 85	W	50	1.00				50	.95	.05			50	1.00		
EAGLE CREEK HATCH. (NATIVE)	W	100	1.00				40	1.00				70	1.00		
EAGLE CREEK HATCHERY 85	W	100	1.00				95	.94	.06			100	1.00		
MARION FORKS HATCHERY	W	90	.94	.06			85	1.00				100	1.00		
THOMAS CREEK 83	W	100	.99	.01			100	1.00				68	1.00		
THOMAS CREEK 84	W	55	.96	.04			55	1.00				55	1.00		
THOMAS CREEK 85	W	24	.94	.06			24	1.00				24	1.00		
WILEY CREEK	W	100	.96	.04			100	1.00				100	1.00		
WILEY CREEK 85	W	27	.96	.04			27	.98	.02			27	1.00		
SOUTH SANTIAM HATCHERY	S	97	.94	.06			97	1.00				47	1.00		
CALAPOOYA RIVER	W	100	1.00									100	1.00		
CALAPOOYA RIVER 84	W	47	.99	.01			47	1.00				47	1.00		
LEABURG HATCHERY	S	95	.95	.05			100	1.00				95	1.00		
LEABURG HATCHERY 85	S	47	.99	.01			43	1.00				50	1.00		
MCKENZIE RIVER	S	50	.97	.03			50	1.00				50	.98		.02
SANDY RIVER	W	100	.96	.04			100	1.00				100	1.00		
WASHOUGAL HATCHERY	S	100	.95	.01		.04	100	1.00				100	.98	.02	
WASHOUGAL HATCHERY 85	S	89	.99	.01			82	.99		.01		100	1.00		
WASHOUGAL HATCHERY	W	100	1.00				100	1.00				100	1.00		
HAMILTON CREEK	W	53	.97	.03			53	.99	.01			53	1.00		
WIND RIVER	S	50	1.00				50	1.00				50	1.00		
WIND RIVER 85	S	25	1.00				25	1.00				25	1.00		
HOOD RIVER	W	50	.99	.01			50	.99	.01			50	.99		.01
KLICKITAT RIVER	S	100	.91	.05	.04		60	1.00				100	1.00		
FIFTEENMILE CREEK	W	82	1.00				82	1.00				82	.96	.01	.03
FIFTEENMILE CREEK 85	W	50	.98	.02			49	.98		.02		50	1.00		
DESCHUTES RIVER	S	264	.92	.06	.01	.01	267	1.00		*		262	.99	*	.01
ROUND BUTTE HATCHERY	S	97	.93	.07			100	.99	.01			78	1.00		
ROUND BUTTE HATCHERY 85	S	98	.91	.08	.01		93	.97		.03		100	.97	.01	.03
JOHN DAY RIVER	S	100	.91	.09			100	1.00				100	.96		.04
JOHN DAY RIVER 85	S	49	.92	.08			51	.98			.02	50	.99		.01

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	DIPEPTIDASE					TRIPEPTIDE AMINOPEPTIDASE					PHOSPHO-GLUCOMUTASE-1			
		N	100	110	85	95	N	100	129	74	50	N	-100	-115	-85
UMATILLA RIVER	S	98	.90	.10			100	1.00				100	1.00		
UMATILLA HATCHERY	S	100	.95	.05			100	.99	.01			100	1.00		
WALLA WALLA RIVER	S	40	.83	.18			40	.90	.04		.06	40	1.00		
TOUCHET RIVER	S	47	.93	.07			48	.98	.02			50	.97	.03	
TUCANNON RIVER	S	112	.88	.11	*		112	1.00	*			100	.99	.01	
TUCANNON RIVER 85	S	50	.90	.10			50	.99	.01			50	1.00		
GRANDE RONDE RIVER	S	50	.93	.04	.03		50	1.00				50	.99		.01
GRANDE RONDE RIVER 84	S	110	.90	.09	.01		110	.99		.01		110	1.00		
WALLOWA-LOSTINE	S	73	1.00				73	1.00				73	1.00		
WALLOWA-LOSTINE 84	S	62	.93	.07			52	1.00				62	1.00		
WALLOWA HATCHERY	S	100	.93	.06	.01		100	1.00				100	1.00		
MISSION CREEK	S	30	.80	.20			30	1.00				30	.98		.02
BIG CANYON/COTTONWOOD CRKS.	S	88	.89	.09	.02		88	1.00				88	.99		.01
DWORSHAK HATCHERY	S	73	.54	.45			73	1.00				73	1.00		
SELWAY RIVER	S	98	.82	.18			98	1.00				95	1.00		
LOCHSA RIVER	S	46	.71	.29			50	1.00				49	1.00		
IMNAHA RIVER	S	100	.97	.03			100	100				96	1.00		
IMNAHA RIVER 84	S	58	.94	.06			58	1.00				58	1.00		
IMNAHA HATCHERY	S	100	.99	.01			100	1.00				100	1.00		
SHEEP & BARGAMIN CRKS.	S	120	.97	.04			120	1.00				120	1.00		
S.F.SALMON (SECESH RIVER)	S	61	.98	.02			57	1.00				61	1.00		
S.F.SALMON (JOHNSON CREEK)	S	50	.83	.16		.01	50	1.00				50	1.00		
CHAMBERLAIN CREEK	S	92	.95	.04		.01	97	1.00							
HORSE CREEK	S	50	.96	.04			51	1.00				50	1.00		
MIDDLE FORK SALMON RIVER #	S	277	.96	.04			277	.99	.01			277	1.00		
PAHSIMEROI 'B' STOCK	S	50	.54	.46			50	1.00				50	1.00		
SAWTOOTH 'A' STOCK	S	50	.95	.05			50	1.00				50	1.00		
HELLS CANYON STOCK	S	96	.96	.04	.01		100	.99	.01			100	1.00		
YAKIMA RIVER	S	48	.91	.09			48	1.00				48	1.00		
YAKIMA RIVER 84	S	49	.82	.18			49	1.00				49	1.00		
WENATCHEE RIVER	S	96	.94	.06			96	1.00				96	1.00		
ENTIAT RIVER	S	49	.96	.04			40	1.00				50	1.00		
WELLS HATCHERY	S	81	.91	.09			81	1.00				61	1.00		
METHOW RIVER	S	58	.95	.05			58	1.00				58	1.00		

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	PHOSPHO-GLUCOMUTASE-2 N	-100	-140	L-IDITOL DEHYDROGENASE N	100	195	SUPEROXIDE DISMUTASE N	100	152	48
BIG CREEK HATCHERY	W	100	1.00		100	1.00		98	.60	.40	
BIG CREEK HATCHERY 85	W	95	1.00					86	.60	.40	
GRAYS RIVER	W	100	1.00		100	1.00		96	.68	.32	.01
ELOCHOMAN HATCHERY	W	100	1.00		100	1.00		98	.68	.32	
COWLITZ HATCHERY NATIVE	W	99	1.00		99	1.00		88	.61	.39	
COWLITZ HATCHERY CHAMBERS	W	100	1.00		100	1.00		100	.66	.34	
COWLITZ HATCHERY -	S	90	1.00		90	1.00		90	.78	.22	
S.F. TOUTLE RIVER	W	50	1.00		50	1.00		49	.58	.42	
COWEEMAN RIVER	W	74	1.00					66	.66	.34	
EAGLE CREEK HATCH. (BIG CR.)	W	100	1.00		100	1.00		99	.65	.35	
EAGLE CREEK HATCHERY 85	W	50	1.00					50	.75	.25	
EAGLE CREEK HATCH. (NATIVE)	W	70	1.00		100	1.00		64	.74	.26	
EAGLE CREEK HATCHERY 85	W	100	1.00					80	.74	.26	
MARION FORKS HATCHERY	W	100	1.00		100	1.00		97	.45	.55	
THOMAS CREEK 83	W	68	1.00					58	.58	.43	
THOMAS CREEK 84	W	55	1.00		55	1.00		55	.63	.37	
THOMAS CREEK 85	W	24	1.00					24	.56	.44	
WILEY CREEK	W	100	1.00		100	1.00		100	.62	.38	
WILEY CREEK 85	W	27	1.00		27	1.00		27	.65	.35	
SOUTH SANTIAM HATCHERY	S	47	1.00		97	1.00		97	.72	.28	
CALAPOOYA RIVER	W	100	1.00					59	.57	.43	
CALAPOOYA RIVER 84	W	47	1.00		47	1.00		47	.59	.41	
LEABURG HATCHERY	S	95	1.00		100	1.00		97	.78	.22	
LEABURG HATCHERY 85	S	50	.97	.03	50	1.00		50	.66	.34	
MCKENZIE RIVER	S	50	1.00		50	1.00		50	.65	.35	
SANDY RIVER	W	100	1.00		100	1.00		99	.76	.24	
WASHOUGAL HATCHERY	S	100	1.00		93	1.00		96	.82	.18	
WASHOUGAL HATCHERY 85	S	100	1.00		100	1.00		98	.69	.31	
WASHOUGAL HATCHERY	W	100	1.00					92	.60	.40	
HAMILTON CREEK	W	53	1.00		53	1.00		53	.71	.29	
WIND RIVER	S	50	1.00		50	1.00		50	.70	.30	
WIND RIVER 85	S	25	1.00					25	.82	.18	
HOOD RIVER	W	50	1.00					47	.73	.27	
KLICKITAT RIVER	S	100	.96	.04	100	1.00		99	.78	.21	.01
FIFTEENMILE CREEK	W	82	1.00		82	1.00		76	.93	.06	.01
FIFTEENMILE CREEK 85	W	50	1.00		50	1.00		50	.79	.15	.06
DESCHUTES RIVER	S	267	1.00					266	.92	.04	.04
ROUND BUTTE HATCHERY	S	78	.99	.01				100	.91	.05	.04
ROUND BUTTE HATCHERY 85	S	100	1.00		100	1.00		98	.87	.09	.05
JOHN DAY RIVER	S	100	1.00					93	.96	.03	.01
JOHN DAY RIVER 85	S	50	1.00		50	1.00		50	.98		.02

Table A2. Steelhead trout gene frequency data (continued).

STEELHEAD STOCK	FORM	PHOSPHO-GLUCOMUTASE-2			L-IDITOL DEHYDROGENASE			SUPEROXIDE DISMUTASE			
		N	-100	-140	N	100	195	N	100	152	48
UMATILLA RIVER	S	100	1.00		100	1.00		96	.95		.05
UMATILLA HATCHERY	S	100	1.00		100	1.00		100	.98	.02	
WALLA WALLA RIVER	S	40	1.00		40	1.00		40	.86	.01	.13
TOUCHET RIVER	S	50	1.00		50	1.00		50	.99		.01
TUCANNON RIVER	S	113	.99	.01	113	1.00		113	.93	.06	.02
TUCANNON RIVER 85	S	50	1.00		50	1.00		50	.94		.06
GRANDE RONDE RIVER	S	50	1.00		50	.93	.07	50	.90	.10	
GRANDE RONDE RIVER 84	S	110	1.00		110	1.00		110	.93	.01	.06
WALLOWA-LOSTINE	S	73	1.00		73	1.00		73	.95	.03	.02
WALLOWA-LOSTINE 84	S	62	.99	.01	62	1.00		62	.90	.03	.07
WALLOWA HATCHERY	S	100	1.00		100	1.00		100	.99		.01
MISSION CREEK	S	30	1.00					30	.92	.07	.02
BIG CANYON/COTTONWOOD CRKS.	S	88	.98	.02				88	.93	.01	.06
DWORSHAK HATCHERY	S	73	1.00					73	1.00		
SELWAY RIVER	S	98	.97	.03				98	.91	.04	.05
LOCHSA RIVER	S	50	1.00					50	.90		.10
IMNAHA RIVER	S	87	1.00		96	1.00		86	.95	.04	.01
IMNAHA RIVER 84	S	58	1.00		58	1.00		58	.90	.02	.09
IMNAHA HATCHERY	S	100	1.00		100	1.00		89	.91	.03	.06
SHEEP & BARGAMIN CRKS.	S	120	.99	.01				120	.87	.01	.13
S.F.SALMON (SECESH RIVER)	S	61	1.00		61	.99	.01	61	.89		.11
S.F.SALMON (JOHNSON CREEK)	S	50	1.00					49	.89	.04	.07
CHAMBERLAIN CREEK	S	97	1.00					97	.96	.01	.03
HORSE CREEK	S	50	1.00					50	1.00		
MIDDLE FORK SALMON RIVER #	S	277	1.00					277	.91	.01	.08
PAHSIMEROI 'B' STOCK	S	50	.99	.01				50	1.00		
SAWTOOTH 'A' STOCK	S	50	1.00					50	.91	.01	.08
HELLS CANYON STOCK	S	100	.99	.01				100	.95	.01	.04
YAKIMA RIVER	S	48	.98	.02	48	1.00		47	.92	.04	.04
YAKIMA RIVER 84	S	49	1.00		49	1.00		49	.86		.14
WENATCHEE RIVER	S	96	1.00					96	.91	.03	.06
ENTIAT RIVER	S	50	1.00		50	1.00		49	.96		.04
WELLS HATCHERY	S	61	1.00					81	.90	.01	.09
METHOW RIVER	S	58	1.00		58	1.00		58	.97	.01	.02

APPENDIX TABLE A3

Chinook salmon meristic character means and standard deviations. Standard deviations are in parentheses. "Year" indicates the year that the stock was sampled. "Form" indicates the time of freshwater entry (S for spring, F for fall and SUM for summer).

Table A3. Chinook meristic character means and standard deviations.

STOCK	FORM	YEAR	SCALES IN LATERAL SERIES	SCALE ROWS	ANAL FIN RAYS	DORSAL FIN RAYS
COWLITZ HATCHERY	F	84	137.65	33.40	15.79	12.50
			(2.80)	(1.89)	(0.63)	(0.51)
COWLITZ HATCHERY	F	85	138.12	31.55	15.60	12.41
			(6.25)	(1.57)	(0.75)	(0.51)
COWLITZ HATCHERY	S	83	135.80	31.45	15.50	12.40
			(3.62)	(2.06)	(0.51)	(0.60)
KALAMA HATCHERY	F	84	138.00	31.30	16.15	12.55
			(4.43)	(1.56)	(0.49)	(0.61)
KALAMA HATCHERY	S	83	138.53	30.68	15.75	12.75
			(4.41)	(1.29)	(0.72)	(0.44)
LEWIS HATCHERY	S	83	143.71	33.10	15.55	12.60
			(2.02)	(1.62)	(0.61)	(0.60)
LEWIS HATCHERY	F	84	136.30	30.75	16.00	12.85
			(3.53)	(1.72)	(0.47)	(0.38)
LEWIS HATCHERY	F	85	136.45	32.05	16.05	12.21
			(2.82)	(1.50)	(0.51)	(0.63)
LEWIS RIVER	F	85	138.12	30.83	16.05	12.15
			(4.73)	(1.43)	(0.52)	(0.59)
CLACKAMAS RIVER	F	85	141.68	31.10	15.80	12.05
			(5.42)	(1.92)	(0.77)	(0.61)
COLLAWASH RIVER	S	84	143.15	31.95	15.55	12.35
			(6.80)	(1.52)	(0.69)	(0.59)
EAGLE CREEK HATCHERY	S	83	139.15	30.60	15.65	12.60
			(3.80)	(1.47)	(0.49)	(0.60)
MARION FORKS HATCHERY	S	85	143.32	31.74	15.95	12.16
			(4.65)	(1.36)	(0.76)	(0.50)
SOUTH SANTIAM HATCHERY	S	83	139.94	31.67	15.65	12.53
			(4.48)	(1.53)	(0.67)	(0.51)
THOMAS CREEK	S	83	140.55	32.00	15.75	12.25
			(3.66)	(1.81)	(0.55)	(0.44)
MCKENZIE HATCHERY	S	83	142.10	32.30	15.50	12.55
			(3.99)	(1.87)	(0.69)	(0.76)
DEXTER HATCHERY	S	83	141.50	30.20	15.74	12.40
			(4.69)	(1.70)	(0.56)	(0.50)
SANDY RIVER	F	84	138.74	30.90	16.05	12.39
			(3.26)	(1.77)	(0.39)	(0.50)
WASHOUGAL RIVER	F	85	139.52	30.72	16.00	12.22
			(3.53)	(1.74)	(0.49)	(0.65)
BONNEVILLE HATCHERY	F	84	136.79	33.68	15.39	12.10
			(2.66)	(1.42)	(0.50)	(0.57)
CARSON HATCHERY	S	83	148.47	32.20	16.31	12.70
			(3.86)	(2.17)	(0.75)	(0.47)
CARSON HATCHERY	S	85	148.47	30.85	16.15	12.55
			(4.90)	(1.14)	(0.59)	(0.51)
LIT.WHITE SALM.HATCH	S	83	142.47	31.06	15.90	12.26
			(3.06)	(1.66)	(0.81)	(0.45)

Table A3. Chinook meristic character means and standard deviations (continued).

STOCK	FORM	YEAR	SCALES IN LATERAL SERIES	SCALE ROWS	ANAL FIN RAYS	DORSAL FIN RAYS
SPRING CREEK HATCHERY	F	84	134.67	33.26	15.12	11.95
			(3.43)	(1.91)	(0.33)	(0.51)
KLICKITAT RIVER	F	85	141.10	30.25	15.95	12.20
			(4.22)	(1.69)	(0.52)	(0.82)
KLICKITAT HATCHERY	S	83	145.05	31.25	16.00	12.61
			(3.82)	(1.65)	(0.56)	(0.50)
DESCHUTES RIVER	F	84	136.55	32.00	16.25	12.30
			(4.20)	(1.37)	(0.64)	(0.57)
ROUND BUTTE HATCHERY	S	83	146.90	32.45	15.95	12.55
			(3.58)	(1.23)	(0.83)	(0.61)
WARM SPRINGS RIVER	S	85	144.85	31.40	15.60	12.25
			(2.25)	(1.43)	(0.60)	(0.44)
JOHN DAY RIVER	S	84	147.50	32.55	15.55	12.45
			(3.71)	(2.04)	(0.69)	(0.61)
JOHN DAY RIVER	S	85	146.95	33.00	15.80	12.45
			(4.08)	(1.52)	(0.62)	(0.51)
SNAKE RIVER STOCK	F	84	143.32	32.05	16.20	12.50
			(4.52)	(2.01)	(0.77)	(0.61)
TUCANNON RIVER	S	84	142.80	31.74	15.95	13.00
			(5.12)	(1.56)	(0.69)	(0.65)
GRANDE RONDE RIVER	S	83	144.53	32.53	15.95	12.35
			(4.85)	(1.66)	(0.61)	(0.49)
GRANDE RONDE RIVER	S	84	141.57	29.74	15.91	12.73
			(6.05)	(1.60)	(0.54)	(0.65)
WALLOWA-LOSTINE RIVER	S	84	146.47	30.64	16.00	12.94
			(3.50)	(1.32)	(0.73)	(0.83)
KOOSKIA HATCHERY STOCK	S	85	143.39	31.60	16.40	12.25
			(4.221	(1.27)	(0.75)	(0.79)
RED R. SF CLEARWATER	S	85	147.53	31.60	16.00	12.45
			(3.17)	(1.64)	(0.56)	(0.51)
IMNAHA RIVER	S	84	149.25	33.30	15.95	12.80
			(5.37)	(1.38)	(0.89)	(0.53)
RAPID RIVER HATCHERY	S	84	145.80	31.05	16.15	12.80
			(2.93)	(1.67)	(0.49)	(0.52)
JOHNSON CREEK	SUM	85	146.42	31.75	16.00	12.50
			(4.93)	(2.14)	(0.43)	(0.67)
McCALL HATCHERY	SUM	84	153.45	32.15	16.50	13.05
			(5.23)	(1.46)	(0.69)	(0.39)
MIDDLE FORK SALMON	S	85	149.84	31.90	16.05	12.70
			(2.97)	(1.94)	(0.69)	(0.47)
EAST FK. SALMON R. STK	S	85	146.70	30.05	15.30	12.30
			(3.75)	(1.75)	(0.80)	(0.66)
VALLEY CREEK	SUM	85	147.15	32.15	15.75	12.25
			(3.31)	(1.57)	(0.55)	(0.55)
VALLEY CREEK	S	85	147.63	31.45	15.70	12.40
			(2.93)	(1.76)	(0.47)	(0.50)

Table A3. Chinook meristic character means and standard deviations (continued).

STOCK	FORM	YEAR	SCALES IN LATERAL SERIES	SCALE ROWS	ANAL FIN RAYS	DORSAL FIN RAYS
SAWTOOTH STOCK	s	84	152.60	32.40	16.25	13.15
			(4.37)	(1.43)	(0.55)	(0.49)
YAKIMA RIVER	F	85	142.78	32.70	16.11	12.20
			(5.47)	(1.77)	(0.78)	(0.42)
YAKIMA RIVER	S	84	149.11	32.79	15.85	12.90
			(5.07)	(1.84)	(0.49)	(0.45)
NACHES RIVER	S	85	147.24	31.60	15.68	12.50
			(3.70)	(1.90)	(0.75)	(0.61)
HANFORD REACH	F	84	140.60	-	16.35	12.40
			(3.52)	-	(0.61)	(0.60)
PRIEST RAPIDS HATCHERY	F	84	137.47	32.00	16.00	12.35
			(3.42)	(1.75)	(0.49)	(0.49)
WENATCHEE RIVER	S	84	144.53	31.30	16.15	12.55
			(5.18)	(1.53)	(0.67)	(0.61)
WENATCHEE RIVER	SUM	85	144.95	32.16	16.20	12.20
			(5.23)	(1.89)	(0.77)	(0.52)
LEAVENWORTH HATCHERY	S	8 3	146.95	30.10	16.25	12.40
			(3.52)	(1.07)	(0.64)	(0.50)
ENTIAT RIVER	S	84	146.50	31.95	16.00	12.70
			(5.32)	(1.57)	(0.73)	(0.47)
WELLS DAM HATCHERY	SUM	84	139.39	31.85	15.53	11.89
			(3.93)	(1.46)	(0.51)	(0.57)
WELLS DAM HATCHERY	SW	85	138.50	31.42	15.75	12.15
			(3.47)	(1.84)	(0.55)	(0.59)
METHOW RIVER	S	84	148.16	32.37	16.05	12.45
			(3.82)	(1.77)	(0.69)	(0.61)
METHOW RIVER	SUM	85	143.45	32.75	16.00	12.10
			(4.54)	(1.52)	(0.78)	(0.45)
WINTHROP HATCHERY	S	85	146.05	31.15	15.90	12.74
			(2.78)	(1.69)	(0.46)	(0.56)
OKANAGAN RIVER	SUM	84	138.05	32.50	16.16	12.33
			(3.99)	(1.32)	(0.60)	(0.49)

Table A3. Chinook meristic character means and standard deviations (continued).

STOCK	FORM	YEAR	PELVIC FIN RAYS	PECTORAL FIN RAYS	GILL RAKERS	LEFT BRANCH.	VERTEBRAE
COWLITZ HATCHERY	F	84	10.10	15.55	9.68	17.37	67.30
			(0.31)	(0.51)	(0.89)	(0.76)	(0.80)
COWLITZ HATCHERY	F	85	9.95	15.50	9.65	17.15	67.15
			(0.22)	(0.61)	(0.88)	(0.81)	(1.09)
COWLITZ HATCHERY	S	83	10.10	15.80	9.30	16.05	67.65
			(0.31)	(0.41)	(0.92)	(1.00)	(1.00)
KALAMA HATCHERY	F	84	9.95	15.75	9.55	17.60	67.50
			(0.22)	(0.55)	(0.76)	(0.88)	(0.76)
KALAMA HATCHERY	S	83	10.05	15.80	10.20	16.95	68.70
			(0.22)	(0.52)	(0.89)	(0.69)	(1.30)
LEWIS HATCHERY	S	83	10.10	15.46	9.11	17.42	71.75
			(0.32)	(0.32)	(0.90)	(0.90)	(0.91)
LEWIS HATCHERY	F	84	10.00	15.54	8.60	17.43	68.13
			(0.00)	(0.52)	(0.63)	(0.94)	(0.52)
LEWIS HATCHERY	F	85	10.05	15.75	9.80	17.85	67.65
			(0.22)	(0.44)	(0.77)	(0.59)	(0.67)
LEWIS RIVER	F	85	9.95	15.75	9.70	18.00	68.30
			(0.22)	(0.44)	(0.80)	(0.80)	(0.92)
CLACKAMAS RIVER	F	85	10.15	15.45	9.75	17.65	68.15
			(0.36)	(0.61)	(0.64)	(0.88)	(1.09)
COLLAWASH RIVER	S	84	10.15	15.25	10.05	17.60	69.00
			(0.37)	(0.72)	(1.05)	(0.88)	(0.80)
EAGLE CREEK HATCHERY	S	83	10.35	15.75	9.85	17.15	68.30
			(0.49)	(0.64)	(0.75)	(0.81)	(0.73)
MARION FORKS HATCHERY	S	85	10.25	15.80	9.00	17.80	69.45
			(0.44)	(0.70)	(0.65)	(0.61)	(1.00)
SOUTH SANTIAM HATCHERY	S	83	10.25	15.75	10.45	16.70	68.40
			(0.44)	(0.64)	(0.61)	(0.57)	(0.68)
THOMAS CREEK	S	83	10.10	15.65	9.35	17.25	69.35
			(0.31)	(0.49)	(0.49)	(0.79)	(0.75)
MCKENZIE HATCHERY	S	83	10.15	15.90	9.80	17.25	68.75
			(0.36)	(0.45)	(0.70)	(0.72)	(0.79)
DEXTER HATCHERY	S	83	10.20	15.70	9.75	17.65	68.95
			(0.41)	(0.66)	(0.72)	(0.93)	(0.95)
SANDY RIVER	F	84	10.00	15.60	8.16	17.65	68.30
			(0.32)	(0.60)	(1.12)	(0.67)	(0.57)
WASHOUGAL RIVER	F	85	10.53	15.68	9.84	17.84	67.95
			(0.23)	(0.67)	(0.69)	(0.83)	(0.78)
BONNEVILLE HATCHERY	F	84	10.21	16.26	9.11	17.42	66.63
			(0.42)	(0.56)	(0.81)	(0.77)	(0.76)
CARSON HATCHERY	S	83	10.15	15.85	9.30	17.35	71.85
			(0.36)	(0.49)	(0.73)	(0.74)	(1.04)
CARSON HATCHERY	S	85	10.00	15.85	9.20	17.90	71.65
			(0.00)	(0.49)	(0.77)	(0.64)	(0.93)
LIT.WHITE SALM.HATCH	S	83	10.00	16.05	8.74	17.32	71.84
			(0.00)	(0.41)	(0.81)	(0.82)	(0.77)

Table A3. Chinook meristic character means and standard deviations (continued).

STOCK	FORM	YEAR	PELVIC FIN RAYS	PECTORAL Fm RAYS	GILL RAKERS	LEFT BRANCH.	VERTEBRAE
SPRING CREEK HATCHERY	F	84	10.05	16.00	9.85	16.00	65.90
			(0.22)	(0.56)	(0.59)	(0.46)	(1.07)
KLICKITAT RIVER	F	85	10.00	15.58	10.40	17.50	69.16
			(0.00)	(0.50)	(0.59)	(0.68)	(1.15)
KLICKITAT HATCHERY	S	83	10.05	16.10	8.95	18.00	71.35
			(0.22)	(0.55)	(0.69)	(0.80)	(1.27)
D - R -	F	84	10.10	15.80	9.42	17.75	67.40
			(0.31)	(0.52)	(0.51)	(0.64)	(1.00)
ROUND BUTTE HATCHERY	S	83	10.05	15.55	9.65	18.00	71.30
			(0.23)	(0.61)	(0.75)	(0.73)	(0.80)
WARM SPRINGS RIVER	s	85	9.72	15.95	9.50	18.40	71.65
			(0.46)	(0.69)	(0.61)	(0.82)	(0.67)
JOHN DAY RIVER	S	84	10.00	15.20	8.37	17.95	72.00
			(0.00)	(0.83)	(0.50)	(0.89)	(0.80)
JOHN DAY RIVER	S	85	10.05	15.80	9.05	18.20	71.20
			(0.22)	(0.41)	(0.78)	(0.70)	(1.06)
SNAKE RIVER STOCK	F	84	10.25	15.90	9.95	17.40	68.00
			(0.45)	(0.45)	(0.89)	(0.75)	(0.73)
TUCANNON RIVER	S	84	10.05	16.00	8.50	18.25	71.45
			(0.22)	(0.46)	(0.51)	(0.64)	(1.10)
GRANDE RONDE RIVER	S	83	10.00	15.65	8.90	17.75	71.85
			(0.32)	(0.49)	(0.72)	(0.85)	(0.93)
GRANDE RONDE RIVER	S	84	10.09	14.89	8.27	17.30	72.00
			(0.54)	(0.78)	(0.65)	(1.06)	(0.78)
WALLOWA-LOSTINE RIVER	S	84	10.12	15.59	8.94	18.00	71.82
			(0.33)	(0.51)	(0.56)	(0.71)	(0.88)
KOOSKIA HATCHERY STOCK	S	85	10.35	15.90	9.15	17.35	72.53
			(0.49)	(0.45)	(0.49)	(0.59)	(1.02)
RED R. SF CLEARWATER	S	85	10.10	15.95	9.20	18.25	71.80
			(0.31)	(0.22)	(0.62)	(0.91)	(0.77)
IMNAHA RIVER	S	84	10.15	15.50	8.95	18.20	71.60
			(0.37)	(0.69)	(0.89)	(0.70)	(0.82)
RAPID RIVER HATCHERY	S	84	10.05	16.00	8.85	17.80	71.45
			(0.22)	(0.56)	(0.75)	(1.01)	(0.83)
JOHNSON CREEK	SUM	85	10.00	15.12	8.83	17.92	72.25
			(0.00)	(0.29)	(0.58)	(0.79)	(0.75)
McCALL HATCHERY	SUM	84	10.10	16.15	9.20	17.45	72.30
			(0.31)	(0.59)	(0.77)	(0.61)	(1.30)
MIDDLE FORK SALMON	S	85	10.05	15.85	9.15	18.10	72.45
			(0.22)	(0.49)	(0.67)	(0.72)	(0.83)
EAST FK. SALMON R. STK	S	85	9.95	15.85	8.25	17.00	72.15
			(0.22)	(0.37)	(0.97)	(0.73)	(0.86)
VALLEY CREEK	SUM	85	10.10	16.00	8.55	17.70	72.21
			(0.31)	(0.32)	(0.83)	(0.87)	(0.92)
VALLEY CREEK	S	85	10.05	15.80	8.30	17.85	72.05
			(0.22)	(0.52)	(0.87)	(0.75)	(0.78)

Table A3. Chinook meristic character means and standard deviations (continued).

STOCK	FORM	YEAR	PELVIC FIN RAYS	PECTORAL FIN RAYS	GILL RAKERS	LEFT BRANCH.	-
SAWTOOTH STOCK	s	84	10.30	16.20	9.25	17.75	72.15
			(0.47)	(0.62)	(0.91)	(0.64)	(0.49)
YAKIMA RIVER	F	85	10.20	15.90	10.10	17.60	70.60
			(0.42)	(0.32)	(0.99)	(0.97)	(1.90)
YAKIMA RIVER	s	84	10.05	16.05	9.50	17.45	71.75
			(0.39)	(0.51)	(0.51)	(0.51)	(0.79)
NACHES RIVER	S	85	10.05	16.05	9.00	18.00	72.00
			(0.22)	(0.39)	(0.73)	(0.92)	(1.12)
HANFORD REACH	F	84	9.90	15.50	8.50	17.84	68.85
			(0.31)	(0.51)	(1.03)	(0.83)	(1.00)
PRIEST RAPIDS HATCHERY	F	84	9.95	15.45	9.15	16.60	68.45
			(0.23)	(0.61)	(0.67)	(0.94)	(0.69)
WENATCHEE RIVER	S	84	10.10	15.15	8.85	18.05	71.75
			(0.31)	(0.93)	(0.75)	(1.10)	(0.85)
WENATCHEE RIVER	SW	85	10.15	15.65	10.65	17.75	69.45
			(0.37)	(0.49)	(0.88)	(0.64)	(0.89)
LEAVENWORTH HATCHERY	S	83	10.30	16.20	9.15	17.90	72.20
			(0.47)	(0.62)	(0.49)	(0.72)	(0.95)
ENTIAT RIVER	S	84	10.00	14.90	8.80	18.00	71.85
			(0.00)	(0.64)	(0.41)	(0.73)	(0.99)
WELLS DAM HATCHERY	SUM	84	10.20	15.65	9.45	16.40	69.20
			(0.41)	(0.49)	(0.51)	(0.75)	(0.95)
WELLS DAM HATCHERY	SUM	85	10.35	16.15	9.35	16.15	68.70
			(0.49)	(0.49)	(0.49)	(0.88)	(0.87)
METHOW RIVER	S	84	10.10	15.85	8.95	17.60	72.20
			(0.31)	(0.49)	(0.69)	(0.82)	(0.89)
METHOW RIVER	SW	85	10.05	15.70	10.35	17.25	69.40
			(0.23)	(0.73)	(0.67)	(0.97)	(1.43)
WINTHROP HATCHERY	S	85	10.15	16.45	9.45	18.25	71.32
			(0.37)	(0.51)	(0.89)	(0.72)	(0.67)
OKANAGAN RIVER	SUM	84	9.90	15.55	9.30	17.85	69.00
			(0.31)	(0.61)	(1.22)	(0.75)	(0.73)

APPENDIX TABLE A4

Steelhead trout meristic character means and standard deviations. Standard deviations are in parentheses. "Year" indicates the year that the stock was sampled. "Form" indicates the time of freshwater entry (S for summer and W for winter).

Table A4. Steelhead meristic character means and standard deviations.

STOCK	FORM	YEAR	SCALES IN LATERAL SERIES	SCALE ROWS	ANAL FIN RAYS	DORSAL FIN RAYS
BIG - HATCHERY	W	83	129.35	23.00	11.50	10.82
			(4.85)	(1.32)	(0.51)	(0.60)
GRAYS RIVER	W	85	128.79	25.00	11.89	11.53
			(3.86)	(1.50	(0.47)	(0.51)
ELOCHOMAN HATCHERY	W	83	128.75	25.80	11.65	11.44
			(3.34)	(1.73)	(0.59)	(0.63)
COWLITZ HATCHERY NATIVE	W	83	126.10	23.84	11.40	11.56
			(3.06)	(1.50)	(0.60)	(0.62)
COWLITZ HATCHERY CHAMBERS	W	83	125.85	24.25	11.45	11.17
			(3.26)	(1.58)	(0.51)	(0.79)
COWLITZ HATCHERY SKAMANIA	S	83	132.50	26.10	11.40	11.40
			(5.09)	(2.07)	(0.68)	(0.51)
S.F. TOUTLE -	W	85	132.90	26.35	11.75	11.65
			(3.51)	(1.84)	(0.55)	(0.67)
COWEEMAN RIVER	W	85	129.18	24.69	12.06	11.53
			(3.71)	(1.92)	(0.75)	(0.51)
EAGLE CREEK HATCH.(BIG CRK.)	W	83	127.05	24.42	10.95	11.70
			(4.77)	(1.50)	(0.68)	(0.75)
EAGLE CREEK HATCH.(NATIVE)	W	83	126.84	24.79	11.90	11.47
			(3.50)	(1.18)	(0.66)	(0.52)
MARION FORKS HATCHERY	W	83	133.11	27.00	11.05	11.24
			(3.85)	(1.56)	(0.52)	(0.44)
THOMAS CREEK	W	83	131.39	27.39	11.33	11.72
			(3.50)	(1.65)	(0.49)	(0.70)
WILEY CREEK	W	84	139.00	29.10	11.10	11.42
			(5.55)	(1.48)	(0.45)	(0.69)
SOUTH SANTIAM HATCHERY	S	85	132.30	24.80	11.00	11.13
			(5.03)	(1.24)	(0.56)	(0.52)
CALAPOOYA RIVER	W	83	135.85	27.85	11.10	11.40
			(4.18)	(1.60)	(0.45)	(0.50)
LEABURG HATCHERY	S	85	135.90	25.50	11.65	11.00
			(3.97)	(1.10)	(0.59)	(0.52)
MCKENZIE RIVER	S	85	136.63	27.63	11.50	11.89
			(5.53)	(1.38)	(0.51)	(0.57)
MCKENZIE HATCHERY	S	84	133.30	25.25	11.70	11.70
			(3.50)	(1.45)	(0.47)	(0.51)
SANDY RIVER	W	84	134.80	27.32	11.75	11.68
			(5.44)	(1.70)	(0.55)	(0.58)
WASHOUGAL H. (SKAMANIA STK)	S	83	133.25	26.53	11.45	11.00
			(4.46)	(1.87)	(0.69)	(0.67)
WASHOUGAL H. (SKAMANIA STK)	S	85	134.70	25.65	11.60	11.92
			(5.23)	(0.98)	(0.50)	(0.29)
WASHOUGAL HATCHERY	W	85	130.45	24.70	11.45	11.50
			(4.06)	(1.84)	(0.61)	(0.52)
HAMILTON CREEK	W	85	133.68	27.10	11.50	11.60
			(6.21)	(1.29)	(0.51)	(0.68)

Table A4. Steelhead characteristic character means and standard deviations (continued).

STOCK	FORM	YEAR	SCALES IN LATERAL SERIES	SCALE ROWS	ANAL FIN RAYS	DORSAL FIN RAYS
WIND RIVER	S	85	146.30	28.40	11.55	11.85
			(7.60)	(1.79)	(0.69)	(0.59)
HOOD RIVER	W	85	135.65	27.00	11.45	11.45
			(6.67)	(2.27)	(0.61)	(0.61)
KLICKITAT RIVER	S	84	144.33	28.56	11.61	11.78
			(7.19)	(1.42)	(0.50)	(0.55)
FIFTEENMILE CREEK	W	83	147.29	29.94	11.55	11.65
			(6.22)	(1.20)	(0.51)	(0.49)
FIFTEENMILE CREEK	W	85	143.70	31.47	11.50	11.75
			(7.16)	(1.35)	(0.51)	(0.64)
DESCHUTES RIVER	S	84	149.37	31.79	11.45	11.95
			(7.00)	(1.99)	(0.61)	(0.61)
ROUND BUTTE HATCHERY	S	83	145.45	29.30	11.50	11.90
			(7.88)	(2.45)	(0.69)	(0.55)
JOHN DAY RIVER	S	84	145.90	30.10	11.45	11.55
			(7.87)	(1.37)	(0.51)	(0.51)
UMATILLA RIVER	S	83	153.26	30.95	11.45	11.80
			(5.52)	(1.73)	(0.76)	(0.62)
UMATILLA RIVER	S	84	151.55	30.95	11.30	11.90
			(8.53)	(2.34)	(0.66)	(0.64)
UMATILLA HATCHERY	S	83	142.85	26.60	10.85	11.33
			(6.36)	(1.76)	(0.59)	(0.49)
WALLA WALLA RIVER	S	85	155.05	31.74	11.20	11.80
			(6.85)	(2.38)	(0.77)	(0.70)
TOUCHET RIVER	S	85	150.25	31.58	11.20	11.85
			(7.07)	(2.32)	(0.70)	(0.59)
TUCANNON RIVER	S	84	147.71	32.29	11.29	11.57
			(7.34)	(2.50)	(0.76)	(0.54)
GRANDE RONDE RIVER	S	83	145.00	30.30	11.35	11.70
			(8.63)	(1.72)	(0.49)	(0.66)
GRANDE RONDE RIVER	S	84	149.41	30.82	11.47	11.42
			(5.51)	(1.51)	(0.61)	(0.69)
WALLOWA-LOSTINE	S	83	147.65	30.76	11.56	11.77
			(5.24)	(1.89)	(0.51)	(0.44)
WALLOWA-LOSTINE	S	84	147.22	30.88	11.65	11.74
			(8.06)	(1.69)	(0.49)	(0.56)
WALLOWA HATCHERY	S	84	146.47	29.17	11.42	11.40
			(6.74)	(1.98)	(0.61)	(0.52)
MISSION CREEK	S	85	151.39	30.90	11.00	11.45
			(7.44)	(1.97)	(0.32)	(0.51)
BIG CANYON/COTTONWOOD CRKS.	S	85	154.70	31.58	11.45	11.95
			(7.48)	(2.14)	(0.61)	(0.61)
DWORSHAK HATCHERY	S	85	146.33	29.60	11.65	11.82
			(8.32)	(1.50)	(0.59)	(0.53)
SELWAY RIVER	S	85	156.10	31.30	11.65	11.55
			(7.89)	(1.81)	(0.49)	(0.61)

Table A4. Steelhead meristic character means and standard deviations (continued).

STOCK	FORM	YEAR	SCALES IN LATERAL SERIES	SCALE ROWS	ANAL FIN RAYS	DORSAL FIN RAYS
LOCHSA RIVER	S	85	154.94	31.47	11.53	11.74
			(7.39)	(1.84)	(0.51)	(0.56)
IMNAHA RIVER	S	83	150.55	30.04	11.55	11.65
			(5.86)	(1.89)	(0.51)	(0.67)
IMNAHA RIVER	S	84	148.11	30.25	11.45	11.75
			(7.65)	(1.52)	(0.51)	(0.55)
IMNAHA HATCHERY	S	84	148.21	28.894	11.47	11.62
			(6.18)	(1.24)	(0.61)	(0.51)
SHEEP & BARGAMIN CRKS.	S	85	150.40	30.55	11.30	11.65
			(9.76)	(2.26)	(0.57)	(0.75)
S.F.SALMON (SECESH RIVER)	S	84	151.10	31.70	11.60	11.65
			(6.94)	(1.83)	(0.49)	(0.75)
S.F.SALMON (JOHNSON CREEK)	S	85	150.44	31.11	11.67	11.67
			(4.22)	(1.27)	(0.50)	(0.50)
CHAMBERLAIN CREEK	S	85	150.47	29.80	11.33	11.67
			(4.97)	(2.40)	(0.49)	(0.72)
HORSE CREEK	S	85	147.07	30.93	11.27	11.47
			(4.86)	(1.75)	(0.59)	(0.64)
MIDDLE FORK SALMON RIVER	S	85	148.25	30.05	11.60	11.70
			(6.82)	(1.27)	(0.68)	(0.66)
PAHSIIYEROI 'B' STOCK	S	85	157.65	31.58	11.70	11.13
			(6.57)	(1.47)	(2.49)	(0.64)
SAWTOOTH 'A' STOCK	S	85	149.05	29.61	10.85	10.86
			(6.79)	(1.85)	(0.49)	(0.36)
HELLS CANYON STOCK	S	85	143.47	28.74	11.28	11.67
			(8.42)	(1.82)	(0.46)	(0.50)
YAKIMA RIVER	S	83	150.83	31.27	11.17	11.58
			(8.60)	(1.74)	(0.39)	(0.52)
YAKIMA RIVER	S	84	153.70	32.45	10.95	11.70
			(6.35)	(1.76)	(0.61)	(0.47)
WENATCHEE RIVER	S	85	147.83	31.33	11.39	11.85
			(9.81)	(1.92)	(0.65)	(0.56)
ENTIAT RIVER	S	84	149.20	29.50	11.60	11.85
			(6.43)	(1.82)	(0.50)	(0.59)
WELLS HATCHERY	S	83	147.80	29.45	11.45	11.56
			(7.48)	(2.14)	(0.61)	(0.78)
METHOW RIVER	S	84	149.61	31.13	11.44	11.89
			(6.69)	(1.78)	(0.62)	(0.58)

Table A4. Steelhead meristic character means and standard deviations (continued)

STOCK	FORM	YEAR	PELVIC FIN BAYS	- FIN BAYS	G I L L RAKERS	LEFT BRANCHIOSTEGALS	VERTEBRAE
BIG CREEK HATCHERY	W	83	9.9	13.90	-7.55	11.50	64.50
			(0.31)	(0.48)	(0.51)	(0.69)	(0.95)
GRAYS RIVER	W	85	10.00	14.53	7.79	11.74	64.53
			(0.00)	(0.51)	(0.63)	(0.65)	(1.26)
- HATCHERY	W	83	9.95	14.05	7.80	11.50	63.80
			(0.39)	(0.39)	(0.77)	(0.61)	(0.52)
COWLITZ HATCHERY NATIVE	W	83	10.00	14.30	6.80	11.45	63.30
			(0.00)	(0.47)	(0.41)	(0.60)	(1.03)
COWLITZ HATCHERY CHAMBERS	W	83	9.95	13.75	7.35	11.65	63.75
			(0.39)	(0.64)	(0.67)	(0.74)	(0.72)
COWLITZ HATCHERY SKAMANIA	S	83	9.95	14.40	7.60	11.70	63.90
			(0.39)	(0.68)	(0.60)	(0.66)	(0.79)
S.F. TOUTLE m	w	85	9.95	14.50	7.60	11.80	64.88
			(0.22)	(0.51)	(0.68)	(0.70)	(0.86)
COWEEMAN RIVER	w	85	9.88	14.53	7.63	12.59	64.56
			(0.33)	(0.51)	(0.62)	(0.62)	(0.89)
- - HATCH.(BIG CRK.)	W	83	9.95	13.75	7.50	11.40	64.50
			(0.22)	(0.71)	(0.61)	(0.60)	(0.89)
EAGLE CREEK HATCH.(NATIVE)	W	83	9.95	14.05	7.26	11.37	64.32
			(0.23)	(0.52)	(0.73)	(0.68)	(0.67)
MARION FORKS HATCHERY	W	83	9.89	14.11	7.21	11.42	65.26
			(0.32)	(0.57)	(0.71)	(0.61)	(0.81)
THOMAS CREEK	W	83	9.94	14.44	7.72	11.78	64.61
			(0.24)	(0.62)	(0.58)	(0.55)	(0.70)
WILEY CREEK	w	85	9.90	14.75	7.60	11.95	64.95
			(0.45)	(0.55)	(0.68)	(0.51)	(0.69)
SOUTH SANTIAM HATCHERY	s	85	9.80	14.35	7.70	11.40	64.74
			(0.41)	(0.67)	(0.66)	(0.68)	(0.81)
CALAPOOYA RIVER	W	83	9.80	14.30	7.30	11.95	64.70
			(0.41)	(0.47)	(0.66)	(0.61)	(0.57)
LEABURG HATCHERY	s	85	9.95	14.15	7.80	11.70	65.00
			(0.22)	(0.37)	(0.62)	(0.57)	(0.89)
MCKENZIE RIVER	s	85	10.10	14.50	8.25	11.95	64.45
			(0.31)	(0.51)	(0.85)	(0.39)	(1.43)
MCKENZIE HATCHERY	s	84	9.90	14.15	7.80	11.70	64.85
			(0.31)	(0.81)	(0.60)	(0.80)	(0.75)
SANDY RIVER	w	84	9.85	14.05	7.35	11.50	65.14
			(0.37)	(0.69)	(0.81)	(0.51)	(0.81)
WASHOUGAL H. (SKAMANIA STK)	S	83	10.00	14.75	7.60	11.45	65.05
			(0.00)	(0.64)	(0.60)	(0.61)	(0.61)
WASHOUGAL H. (SKAMANIA STK)	S	85	10.00	14.25	7.50	11.70	65.00
			(0.00)	(0.44)	(1.00)	(0.66)	(0.92)
WASHOUGAL HATCHERY	w	85	9.85	13.90	7.90	11.35	65.35
			(0.36)	(0.55)	(0.64)	(0.49)	(1.14)
HAMILTON CREEK	W	85	10.00	14.20	7.95	12.00	64.55
			(0.00)	(0.52)	(0.76)	(0.80)	(0.83)

Table A4. Steelhead meristic charactermeans andstandard **deviations (continued).**

STOCK	FORM	YEAR	PELVIC FIN RAYS	PECTORAL FIN RAYS	GILL RAKERS	LEFT BRANCHIOSTEGALS	VERTEBRAE
WIND RIVER	S	85	9.90	14.30	7.60	11.90	65.35
			(0.31)	(0.66)	(0.68)	(0.72)	(0.49)
HOOD RIVER	W	85	9.85	14.10	7.85	11.65	64.20
			(0.37)	(0.55)	(0.75)	(0.59)	(0.62)
KLICKITAT RIVER	S	84	9.90	14.26	7.79	11.68	64.79
			(0.46)	(0.73)	(0.54)	(0.75)	(1.08)
FIFTEENMILE CREEK	W	83	9.85	14.20	7.05	12.05	64.70
			(0.37)	(0.41)	(0.83)	(0.51)	(0.87)
FIFTEENMILE CREEK	W	85	9.85	14.35	7.30	11.25	64.30
			(0.37)	(0.59)	(0.66)	(0.44)	(0.98)
DESCHUTES RIVER	S	84	9.80	13.90	7.47	11.47	64.35
			(0.41)	(0.72)	(0.90)	(0.70)	(0.75)
ROUND BUTTE HATCHERY	S	83	9.95	13.65	7.90	11.70	63.45
			(0.39)	(0.49)	(0.72)	(0.66)	(0.76)
JOHN DAY RIVER	S	84	9.65	13.95	7.20	11.35	64.20
			(0.49)	(0.39)	(0.52)	(0.59)	(1.11)
UMATILLA RIVER	S	83	10.05	14.15	7.10	11.70	64.45
			(0.22)	(0.75)	(0.48)	(0.48)	(0.69)
UMATILLA RIVER	S	84	9.80	13.90	7.30	11.50	64.50
			(0.41)	(0.31)	(0.66)	(0.69)	(0.89)
UMATILLA HATCHERY	S	83	9.70	14.00	7.65	11.00	64.20
			(0.47)	(0.00)	(0.59)	(0.65)	(0.62)
WALLA WALLA RIVER	S	85	10.05	13.95	7.25	11.65	64.45
			(0.39)	(0.76)	(0.55)	(0.59)	(0.76)
TOUCHET RIVER	S	85	9.70	13.80	7.85	11.40	64.15
			(0.47)	(0.77)	(0.59)	(0.60)	(0.81)
TUCANNON RIVER	S	84	10.00	13.86	7.43	11.71	65.14
			(0.00)	(0.69)	(0.79)	(0.76)	(0.90)
GRANDE RONDE RIVER	S	83	9.85	14.20	7.20	11.30	64.45
			(0.37)	(0.52)	(0.70)	(0.73)	(1.00)
GRANDE RONDE RIVER	S	84	9.58	13.53	7.32	11.05	64.32
			(0.51)	(0.51)	(0.67)	(0.52)	(0.89)
WALLOWA-LOSTINE	S	83	9.76	14.29	7.18	11.18	64.00
			(0.56)	(0.47)	(0.64)	(0.53)	(0.79)
WALLOWA-LOSTINE	S	84	9.74	14.00	7.35	11.35	64.25
			(0.45)	(0.56)	(0.49)	(0.49)	(0.91)
WALLOWA HATCHERY	S	84	10.00	14.00	7.74	11.47	64.00
			(0.00)	(0.58)	(0.73)	(0.70)	(0.58)
MISSION CREEK	S	85	9.95	14.15	7.20	11.85	63.65
			(0.22)	(0.37)	(0.70)	(0.59)	(1.18)
BIG CANYON/COTTONWOOD CRKS.	S	85	9.75	14.25	7.90	11.60	64.16
			(0.44)	(0.64)	(0.64)	(0.60)	(0.77)
- HATCHERY	S	85	9.85	13.90	7.20	11.65	64.45
			(0.37)	(0.55)	(0.70)	(0.49)	(0.83)
SELWAY RIVER	S	85	9.80	14.15	7.15	11.30	64.45
			(0.41)	(0.49)	(0.67)	(0.57)	(0.69)

Table A4. Steelhead meristic character means and standard deviations (continued).

STOCK	FORM	YEAR	PELVICFIN RAYS	PECTORAL FIN BAYS	GILL RAKERS	LEFT BRANCHIOSTEGALS	VERTEBRAE
LOCHSA RIVER	s	85	9.84	14.00	7.42	11.32	64.90
			(0.50)	(0.58)	(0.51)	(0.48)	(0.81)
IMNAHA RIVER	S	83	9.85	14.45	7.70	11.70	64.25
			(0.37)	(0.51)	(0.66)	(0.66)	(0.72)
IMNAHA RIVER	s	84	9.85	14.25	7.15	11.55	64.25
			(0.37)	(0.44)	(0.37)	(0.83)	(0.72)
IMNAHA HATCHERY	s	84	10.00	14.26	7.28	11.58	64.47
			(0.33)	(0.81)	(0.67)	(0.77)	(0.61)
SHEEP & BARGAMIN CRKS.	S	85	10.00	14.25	7.65	11.60	64.45
			(0.00)	(0.44)	(0.67)	(0.50)	(0.69)
S.F.SALMON (SECESH RIVER)	s	84	10.05	14.15	7.65	11.90	65.15
			(0.39)	(0.67)	(0.49)	(0.72)	(0.88)
S.F.SALMON (JOHNSON CREEK)	S	85	10.11	14.22	7.33	-11.44	65.44
			(0.33)	(0.67)	(0.50)	(0.53)	(0.88)
CHAMBERLAIN CREEK	s	85	9.87	14.13	7.33	11.67	63.93
			(0.35)	(0.64)	(0.49)	(0.49)	(0.80)
HORSE CREEK	s	85	9.93	14.60	7.60	11.20	64.40
			(0.26)	(0.63)	(0.63)	(0.68)	(0.99)
MIDDLE FORK SALMON RIVER	S	85	9.90	14.25	7.30	11.80	64.35
			(0.31)	(0.44)	(0.47)	(0.62)	(0.75)
PAHSIMEROI 'B' STOCK	s	85	9.70	14.35	7.35	10.80	64.80
			(0.47)	(0.49)	(0.49)	(0.70)	(0.83)
SAWTOOTH 'A' STOCK	s	85	9.85	14.05	7.30	10.80	64.10
			(0.49)	(0.51)	(0.66)	(0.52)	(1.17)
HELLS CANYON STOCK	s	85	9.47	14.16	7.32	11.37	63.74
			(0.51)	(0.69)	(0.67)	(0.60)	(0.65)
YAKIMA RIVER	S	83	9.92	14.00	7.75	11.50	64.42
			(0.29)	(0.43)	(0.75)	(0.52)	(1.31)
YAKIMA RIVER	s	84	9.85	13.90	7.30	11.25	64.25
			(0.49)	(0.64)	(0.66)	(0.44)	(1.07)
WENATCHEE RIVER	s	85	9.85	14.08	7.46	11.77	64.46
			(0.38)	(0.76)	(0.66)	(0.73)	(0.78)
ENTIAT RIVER	s	84	9.80	14.16	7.65	11.60	64.45
			(0.41)	(0.83)	(0.75)	(0.50)	(0.69)
WELLS HATCHERY	S	83	10.00	14.00	7.80	11.50	63.60
			(0.32)	(0.65)	(0.83)	(0.61)	(1.10)
METHOW RIVER	s	84	9.89	13.78	7.06	11.44	64.11
			(0.32)	(0.43)	(0.54)	(0.62)	(0.83)

APPENDIX TABLE A5

Chinook salmon body shape character means and standard deviations. Standard deviations are in square parentheses. Numbers in round parentheses are landmark points on the body of the fish (see Figure 5 for key). "Year" indicates the year that the stock was sampled. "Form" indicates the time of freshwater entry (S for spring, F for fall and SUM for summer).

Table A5. Chinook body shape characters.

STOCK	FORM	YEAR	HEAD WIDTH	HEAD LENGTH (1x16)	HEAD DEPTH (2x15)	TOP OF HEAD TO INSERT. PECTORAL (2x14)	SNOUT TO TOP OF HEAD (1x2)	INTER-ORBITAL WIDTH
COWLITZ HATCHERY	F	84	8.354	21.169	15.740	14.963	16.404	5.804
			[0.24]	[0.55]	[0.51]	[0.43]	[0.49]	[0.16]
COWLITZ HATCHERY	F	85	8.518	21.659	15.894	14.938	16.596	5.780
			[0.36]	[0.73]	[0.47]	[0.56]	[0.53]	[0.35]
COWLITZ HATCHERY	S	85	8.679	21.305	16.499	15.397	16.248	5.591
			[0.45]	[0.63]	[0.78]	[0.58]	[0.50]	[0.25]
KALAMA HATCHERY	F	84	8.163	19.906	16.558	14.585	15.988	5.545
			[0.20]	[0.59]	[0.38]	[0.32]	[0.41]	[0.17]
KALAMA HATCHERY	S	85	9.184	20.900	16.813	15.172	16.999	6.010
			[0.47]	[0.73]	[0.35]	[0.41]	[0.32]	[0.29]
LEWIS HATCHERY	S	85	8.886	21.057	16.113	14.955	16.282	5.611
			[0.41]	[0.56]	[0.53]	[0.51]	[0.52]	[0.27]
LEWIS HATCHERY	F	85	8.569	20.836	16.039	14.856	16.009	5.468
			[0.27]	[0.54]	[0.46]	[0.22]	[0.37]	[0.17]
LEWIS RIVER	F	85	8.305	20.587	15.326	14.666	16.061	5.538
			[0.18]	[0.53]	[0.38]	[0.48]	[0.32]	[0.18]
CLACKAMAS RIVER	F	85	8.812	21.371	16.294	14.702	16.939	5.536
			[0.49]	[0.60]	[0.40]	[0.31]	[0.43]	[0.29]
CLACKAMAS RIVER	S	84	8.836	21.733	15.902	14.362	17.215	5.857
			[0.27]	[0.50]	[0.64]	[0.52]	[0.69]	[0.25]
EAGLE CREEK HATCHERY	S	85	8.976	20.436	16.432	14.607	16.916	5.669
			[0.34]	[0.77]	[0.44]	[0.56]	[0.53]	[0.25]
MARION FORKS HATCHERY	S	85	8.972	20.242	16.539	14.809	15.574	5.369
			[0.55]	[0.70]	[0.65]	[0.38]	[0.42]	[0.17]
SOUTH SANTIAM HATCHERY	S	85	8.171	20.868	16.166	14.726	16.182	5.519
			[0.32]	[0.55]	[0.57]	[0.54]	[0.42]	[0.20]
THOMAS CREEK	S	83	8.350	21.155	15.438	14.219	16.893	5.484
			[0.21]	[0.39]	[0.53]	[0.35]	[0.47]	[0.17]
MCKENZIE HATCHERY	S	83	8.776	18.131	18.084	15.091	17.444	6.241
			[0.36]	[0.65]	[0.49]	[0.44]	[0.39]	[0.28]
MCKENZIE HATCHERY	S	85	9.109	20.345	16.864	14.142	17.729	5.982
			[0.43]	[0.92]	[0.46]	[0.49]	[0.44]	[0.16]
DEXTER HATCHERY	S	85	8.255	20.291	15.607	14.096	16.043	5.401
			[0.26]	[0.94]	[0.50]	[0.58]	[0.41]	[0.24]
SANDY RIVER	F	85	9.163	21.323	16.431	14.749	17.076	5.613
			[0.43]	[0.46]	[0.47]	[0.35]	[0.37]	[0.28]
WASHOUGAL RIVER	F	85	9.355	22.127	16.454	14.879	17.434	5.681
			[0.30]	[0.42]	[0.53]	[0.32]	[0.46]	[0.26]
BONNEVILLE HATCHERY	F	84	7.752	20.683	16.060	15.031	15.762	5.465
			[0.23]	[0.55]	[0.45]	[0.49]	[0.34]	[0.20]
CARSON HATCHERY	S	84	8.563	20.640	16.399	14.653	16.592	5.550
			[0.22]	[0.86]	[0.60]	[0.66]	[0.45]	[0.23]
CARSON HATCHERY	S	85	9.277	20.293	16.517	14.938	16.365	5.788
			[0.42]	[0.62]	[0.50]	[0.40]	[0.31]	[0.22]

Table A5. Chinook body shape characters (continued).

STOCK	FORM	YEAR	HEAD WIDTH	HEAD LENGTH (1x16)	HEAD DEPTH (2x15)	TOP OF HEAD TO INSERT. PECTORAL (2x14)	SNOUT TO TOP OF HEAD (1x2)	INTER-ORBITAL WIDTH
LIT.WHITE SALMON HATCH.	S	83	8.585 [0.31]	20.220 [0.77]	15.541 [0.37]	14.565 [0.46]	16.309 [0.63]	5.915 [0.19]
LIT.WHITE SALMON HATCH.	S	85	8.809 [0.48]	18.965 [0.53]	16.078 [0.42]	14.903 [0.38]	15.481 [0.35]	5.301 [0.27]
SPRING CREEK HATCHERY	F	84	7.939 [0.17]	21.273 [0.70]	15.452 [0.32]	14.482 [0.43]	16.150 [0.33]	5.593 [0.17]
KLICKITAT RIVER	F	85	8.768 [0.53]	21.755 [0.52]	16.370 [0.45]	14.781 [0.33]	17.300 [0.27]	5.532 [0.34]
KLICKITAT HATCHERY	S	83	9.353 [0.38]	20.054 [0.89]	17.104 [0.45]	15.348 [0.49]	17.126 [0.65]	6.054 [0.29]
KLICKITAT HATCHERY	S	85	9.078 [0.38]	20.569 [0.66]	16.065 [0.30]	14.599 [0.25]	16.777 [0.37]	5.638 [1.71]
DESCHUTES RIVER	F	84	8.179 [0.22]	20.893 [0.58]	15.754 [0.41]	14.839 [0.43]	15.871 [0.27]	5.513 [0.14]
ROUND BUTTE HATCHERY	S	83	8.327 [0.28]	20.380 [0.72]	15.753 [0.36]	14.413 [0.33]	15.596 [0.35]	5.458 [0.93]
WARM SPRINGS RIVER	S	85	9.015 [0.41]	20.120 [1.02]	16.447 [0.49]	14.968 [0.53]	16.416 [0.52]	5.685 [0.41]
JOHN DAY RIVER	S	84	8.554 [0.23]	19.435 [0.46]	15.837 [0.51]	14.316 [0.60]	15.293 [0.46]	5.396 [0.26]
JOHN DAY RIVER	S	85	8.950 [0.27]	20.621 [0.58]	16.250 [0.45]	15.006 [0.42]	16.297 [0.45]	5.684 [0.26]
SNAKE RIVER STOCK	F	84	9.017 [0.26]	22.712 [0.72]	17.049 [0.69]	15.156 [0.39]	17.500 [0.60]	5.308 [0.16]
TUCANNON RIVER	S	84	8.767 [0.24]	20.627 [0.76]	16.052 [0.42]	15.090 [0.38]	15.503 [0.42]	5.834 [0.29]
GRANDE RONDE RIVER	S	83	8.582 [0.21]	20.343 [0.56]	15.882 [0.55]	14.143 [0.43]	16.237 [0.45]	5.730 [0.26]
GRANDE RONDE RIVER	S	84	9.177 [0.25]	21.416 [1.07]	15.632 [0.92]	15.173 [0.85]	16.447 [1.01]	6.527 [0.55]
WALLOWA-LOSTINE RIVER	S	84	8.717 [0.22]	19.679 [0.49]	15.973 [0.51]	14.627 [0.41]	16.153 [0.50]	5.674 [0.27]
RED R. SF CLEARWATER	S	85	9.020 [0.23]	19.709 [0.57]	16.727 [0.55]	14.978 [0.41]	16.101 [0.34]	5.803 [0.14]
IMNAHA RIVER	S	84	9.116 [0.33]	20.791 [0.51]	17.174 [0.56]	15.885 [0.44]	16.502 [0.57]	5.979 [0.23]
KOOSKIA HATCHERY STOCK	S	85	8.793 [0.36]	19.854 [0.72]	16.309 [0.53]	14.527 [0.44]	16.297 [0.36]	5.584 [0.27]
RAPID RIVER HATCHERY	S	84	8.678 [0.36]	19.202 [0.60]	16.008 [0.40]	14.505 [0.42]	15.742 [0.27]	5.341 [0.19]
JOHNSON CREEK	SUM	85	8.681 [0.25]	21.448 [0.56]	15.202 [0.42]	14.719 [0.49]	15.980 [0.55]	5.845 [0.20]
McCALL HATCHERY	SUM	84	8.664 [0.42]	19.846 [0.70]	15.940 [0.49]	14.324 [0.45]	16.526 [0.41]	5.613 [0.16]

Table A5. Chinook body shape characters (continued).

STOCK	FORM	YEAR	HEAD WIDTH	HEAD LENGTH (1x16)	HEAD DEPTH (2x15)	TOP OF HEAD TO INSERT. PECTORAL (2x14)	SNOUT TO TOP OF HEAD (1x2)	INTER-ORBITAL WIDTH
MIDDLE FORK SALMON	S	85	8.968	20.824	15.978	14.784	16.164	5.634
			[0.27]	[0.50]	[0.53]	[0.55]	[0.37]	[0.32]
EAST FK. SALMON R.	S	85	8.893	19.849	16.174	14.334	16.230	5.964
			[0.29]	[0.56]	[0.49]	[0.41]	[0.44]	[0.30]
VALLEY CREEK	SUM	85	8.907	20.509	15.635	14.148	16.170	5.695
			[0.18]	[0.53]	[0.36]	[0.53]	[0.29]	[0.22]
VALLEY CREEK	S	85	8.779	21.814	17.000	15.301	16.693	5.779
			[0.30]	[0.73]	[0.60]	[0.45]	[0.44]	[0.33]
SAWTOOTH STOCK	S	84	8.860	19.675	15.770	14.471	16.126	5.435
			[0.46]	[1.08]	[0.34]	[0.38]	[0.41]	[0.18]
YAKIMA RIVER	F	85	8.683	22.654	15.705	14.821	16.718	5.897
			[0.26]	[0.61]	[0.18]	[0.31]	[0.34]	[0.23]
YAKIMA RIVER	S	85	8.985	21.300	16.086	14.998	16.407	5.914
			[0.25]	[0.78]	[0.48]	[0.61]	[0.48]	[0.24]
NACHES RIVER	S	85	8.479	20.721	15.194	13.918	16.364	5.624
			[0.24]	[0.57]	[0.27]	[0.24]	[0.33]	[0.20]
HANFORD REACH	F	85	8.588	22.187	16.309	14.993	17.072	5.607
			[0.42]	[0.69]	[0.47]	[0.49]	[0.52]	[0.24]
PRIEST RAPIDS HATCHERY	F	84	7.112	20.018	16.003	14.599	16.956	4.804
			[0.22]	[0.57]	[0.35]	[0.35]	[0.49]	[0.16]
WENATCHEE RIVER	S	84	9.060	21.298	16.266	15.374	16.546	5.858
			[0.22]	[0.57]	[0.67]	[0.69]	[0.76]	[0.24]
WENATCHEE RIVER	SUM	85	8.432	19.794	15.622	14.445	16.229	5.486
			[0.38]	[2.18]	[0.52]	[0.33]	[0.41]	[0.38]
LEAVENWORTH HATCHERY	S	85	8.616	20.406	16.125	14.541	16.464	5.348
			[0.25]	[0.65]	[0.34]	[0.38]	[0.56]	[0.16]
ENTIAT RIVER	S	84	9.360	20.821	16.179	14.559	16.418	6.121
			[0.41]	[0.72]	[0.52]	[0.38]	[0.63]	[0.36]
WELLS DAM HATCHERY	SUM	84	7.947	20.451	15.295	14.305	15.794	5.398
			[0.18]	[0.53]	[0.37]	[0.33]	[0.40]	[0.14]
WELLS DAM HATCHERY	SUM	85	8.337	21.082	15.449	14.591	15.860	5.605
			[0.67]	[0.50]	[0.40]	[0.42]	[0.34]	[0.31]
METHOW RIVER	S	84	8.743	19.764	15.391	14.298	16.292	5.688
			[0.23]	[0.23]	[0.43]	[0.43]	[0.66]	[0.18]
METHOW RIVER	SUM	85	8.211	20.840	15.923	14.821	16.398	5.338
			[0.25]	[0.73]	[0.52]	[0.45]	[0.41]	[0.21]
WINTHROP HATCHERY	S	85	9.229	20.229	17.289	15.900	17.113	5.881
			[0.39]	[0.86]	[0.56]	[0.55]	[0.58]	[0.23]
OKANAGAN RIVER	SUM	84	7.781	19.872	15.639	14.997	15.109	5.397
			[0.20]	[0.43]	[0.44]	[0.32]	[0.50]	[0.27]
OKANAGAN RIVER	SUM	85	7.911	20.702	15.731	14.512	16.272	5.280
			[0.39]	[0.51]	[0.39]	[0.44]	[0.48]	[0.16]

Table A5. Chinook body shape characters (continued).

STOCK	FORM	YEAR	CAUDAL FIN (6x20)	CAUDAL FIN (6x21)	CAUDAL FIN (8x21)	CAUDAL FIN (8x20)	CAUDAL LENGTH (6x9)	CAUDAL LENGTH (4x7)	CAUDAL DEPTH (4x9)
COWLITZ HATCHERY	F	84	17.874	22.166	18.456	22.973	11.224	35.894	23.963
			[0.79]	[0.71]	[0.52]	[0.79]	[0.51]	[0.71]	[0.60]
COWLITZ HATCHERY	F	85	19.108	22.248	19.738	23.560	11.658	35.920	23.673
			[0.66]	[0.89]	[0.79]	[0.96]	[0.46]	[0.73]	[0.55]
COWLITZ HATCHERY	S	85	18.732	22.551	19.134	23.266	11.662	35.573	23.654
			[0.53]	[0.63]	[0.85]	[0.71]	[0.46]	[0.65]	[0.53]
KALAMA HATCHERY	F	84	18.284	23.726	20.264	23.578	11.078	35.102	23.137
			[0.73]	[0.82]	[0.77]	[0.69]	[0.60]	[0.85]	[0.71]
KALAMA HATCHERY	S	85	18.650	21.677	18.611	22.702	11.586	34.790	23.312
			[0.72]	[0.92]	[1.04]	[0.68]	[0.46]	[0.54]	[0.46]
LEWIS HATCHERY	S	85	19.426	23.069	19.471	23.549	11.040	35.354	23.464
			[0.52]	[0.74]	[0.62]	[0.63]	[0.55]	[0.51]	[0.63]
LEWIS HATCHERY	F	85	18.460	22.790	19.100	23.187	11.299	35.392	23.573
			[0.68]	[0.68]	[0.67]	[0.61]	[0.36]	[0.62]	[0.63]
LEWIS RIVER	F	85	21.039	23.938	21.484	24.739	11.523	35.449	23.795
			[0.97]	[0.71]	[0.68]	[0.76]	[0.41]	[0.71]	[0.56]
CLACKAMAS RIVER	F	85	20.280	24.574	20.825	24.397	11.283	35.348	23.493
			[0.80]	[0.81]	[0.72]	[0.73]	[0.60]	[0.98]	[0.88]
CLACKAMAS RIVER	S	84	21.130	24.928	21.390	25.369	10.715	35.339	23.705
			[1.39]	[0.79]	[0.95]	[0.89]	[0.75]	[0.55]	[0.55]
EAGLE CREEK HATCHERY	S	85	18.381	21.442	18.776	22.119	11.087	35.512	23.694
			[1.02]	[1.33]	[0.75]	[0.82]	[0.50]	[0.69]	[0.70]
MARION FORKS HATCHERY	S	85	17.262	21.607	18.838	21.557	11.559	35.160	24.156
			[0.76]	[0.77]	[0.91]	[0.62]	[0.45]	[0.79]	[0.73]
SOUTH SANTIAM HATCHERY	S	85	18.645	22.134	18.861	22.981	10.975	35.046	23.563
			[0.80]	[0.88]	[0.86]	[0.88]	[0.37]	[0.71]	[0.48]
THOMAS CREEK	S	83	20.885	24.494	20.886	25.451	10.845	35.281	22.861
			[0.80]	[0.69]	[0.76]	[0.72]	[0.55]	[0.80]	[0.63]
MCKENZIE HATCHERY	S	83	20.634	25.218	22.586	26.108	9.862	35.755	25.042
			[1.03]	[0.75]	[1.39]	[0.96]	[0.51]	[0.75]	[0.72]
MCKENZIE HATCHERY	S	85	19.280	23.379	19.609	22.562	11.119	33.384	21.610
			[0.79]	[0.47]	[0.65]	[0.64]	[0.46]	[0.48]	[0.57]
DEXTER HATCHERY	S	85	18.055	21.406	18.415	21.872	11.053	35.276	23.484
			[0.46]	[0.55]	[0.62]	[0.61]	[0.41]	[0.70]	[0.46]
SANDY RIVER	F	85	20.098	24.218	20.133	24.425	10.900	35.190	23.737
			[0.80]	[0.44]	[0.75]	[0.59]	[0.29]	[0.84]	[0.79]
WASHOUGAL RIVER	F	85	20.528	24.725	20.413	24.670	11.073	34.676	23.247
			[0.45]	[0.97]	[0.64]	[0.72]	[0.53]	[0.88]	[0.51]
BONNEVILLE HATCHERY	F	84	15.792	—	—	20.663	11.103	35.165	24.231
			[0.62]	—	—	[0.24]	[0.53]	[0.82]	[0.66]
CARSON HATCHERY	S	84	18.475	22.926	18.645	23.481	11.206	34.296	23.050
			[1.47]	[1.27]	[1.47]	[0.70]	[0.80]	[0.53]	[0.42]
CARSON HATCHERY	S	85	18.229	22.272	19.103	23.173	11.897	35.275	23.424
			[1.00]	[0.79]	[0.84]	[0.61]	[0.61]	[0.61]	[0.65]

Table A5. Chinook body shape characters (continued).

STOCK	FORM	YEAR	CAUDAL FIN (6x20)	CAUDAL FIN (6x21)	CAUDAL FIN (8x21)	CAUDAL FIN (8x20)	CAUDAL LENGTH (6x9)	CAUDAL LENGTH (4x7)	CAUDAL DEPTH (4x9)
LIT.WHITE SALMON HATCH.	S	83	19.262	26.506	19.884	23.275	10.868	36.744	24.062
			[0.72]	[0.60]	[0.89]	[0.55]	[0.57]	[0.82]	[0.68]
LIT.WHITE SALMON HATCH.	S	85	18.842	22.407	19.687	23.677	11.497	36.214	24.035
			[0.77]	[0.59]	[0.60]	[0.43]	[0.46]	[0.70]	[0.52]
SPRING CREEK HATCHERY	F	84	15.771	21.893	16.876	19.716	11.307	36.123	24.203
			[0.97]	[0.61]	[0.95]	[0.84]	[0.42]	[0.68]	[0.68]
KLICKITAT RIVER	F	85	20.523	24.275	21.055	24.202	11.241	34.672	23.052
			[0.72]	[0.68]	[0.72]	[0.67]	[0.52]	[1.29]	[1.09]
KLICKITAT HATCHERY	S	83	--	23.028	16.252	--	11.233	34.497	23.531
			--	[0.51]	[0.32]	--	[0.53]	[0.53]	[0.55]
KLICKITAT HATCHERY	S	85	19.403	22.724	19.522	23.430	10.968	35.396	23.282
			[0.72]	[0.67]	[0.79]	[0.63]	[0.40]	[0.58]	[0.58]
DESCHUTES RIVER	F	84	16.995	23.027	18.419	22.116	10.632	35.260	24.000
			[1.07]	[1.13]	[1.02]	[1.12]	[0.58]	[0.66]	[0.65]
ROUND BUTTE HATCHERY	S	85	18.891	21.736	18.438	22.923	10.762	34.621	23.345
			[0.89]	[0.65]	[0.74]	[0.71]	[0.53]	[0.74]	[0.60]
WARM SPRINGS RIVER	S	85	18.886	22.478	19.914	23.628	11.543	35.319	23.421
			[0.67]	[0.71]	[0.78]	[0.73]	[0.37]	[0.59]	[0.64]
JOHN DAY RIVER	S	84	19.686	24.178	17.274	24.759	11.487	36.039	24.299
			[0.60]	[0.90]	[0.61]	[1.09]	[0.68]	[0.67]	[0.62]
JOHN DAY RIVER	S	85	22.759	21.736	23.186	28.110	11.405	34.531	22.775
			[0.62]	[0.65]	[0.77]	[0.80]	[0.41]	[0.78]	[0.62]
SNAKE RIVER STOCK	F	84	17.585	20.503	18.221	22.333	9.587	35.506	24.918
			[0.87]	[0.79]	[0.91]	[1.10]	[0.41]	[0.69]	[0.76]
TUCANNON RIVER	S	84	19.436	25.159	22.249	25.611	11.489	35.753	24.613
			[0.51]	[1.03]	[0.88]	[0.86]	[0.52]	[0.65]	[0.71]
GRANDE RONDE RIVER	S	83	20.446	24.847	20.824	25.415	10.978	35.118	23.541
			[0.68]	[0.54]	[0.80]	[0.56]	[0.40]	[1.04]	[0.68]
GRANDE RONDE RIVER	S	84	20.016	--	--	24.698	10.662	35.156	23.296
			[2.01]	--	--	[1.81]	[0.65]	[0.77]	[0.46]
WALLOWA-LOSTINE RIVER	S	84	19.625	24.336	19.932	24.995	10.251	35.213	23.863
			[0.78]	[0.98]	[1.05]	[0.75]	[0.44]	[0.82]	[0.74]
RED R. SF CLEARWATER	S	85	19.977	23.998	20.867	24.609	11.246	34.569	23.240
			[0.44]	[0.54]	[0.48]	[0.70]	[0.48]	[0.70]	[0.71]
IMNAHA RIVER	S	84	20.108	23.590	20.696	25.046	11.732	35.211	24.350
			[0.73]	[1.19]	[1.45]	[0.78]	[0.74]	[0.87]	[0.75]
KOOSKIA HATCHERY STOCK	S	85	19.058	22.268	18.854	23.408	11.477	34.927	22.685
			[0.64]	[0.79]	[0.85]	[0.61]	[0.40]	[0.60]	[0.54]
RAPID RIVER HATCHERY	S	84	18.550	21.908	18.485	23.371	11.177	35.367	23.406
			[0.49]	[0.40]	[0.58]	[0.70]	[0.53]	[0.50]	[0.46]
JOHNSON CREEK	SUM	85	21.414	24.252	22.192	25.970	11.322	35.486	22.863
			[0.83]	[0.60]	[0.71]	[0.78]	[0.42]	[1.18]	[0.74]
McCALL HATCHERY	SUM	84	18.657	22.940	19.328	23.374	11.354	35.009	23.020
			[0.87]	[0.80]	[0.85]	[0.60]	[0.43]	[0.86]	[0.73]

Table A5. Chinook body shape characters (continued).

STOCK	FORM	YEAR	CAUDAL FIN (6x20)	CAUDAL FIN (6x21)	CAUDAL FIN (8x21)	CAUDAL FIN (8x20)	CAUDAL LENGTH (6x9)	CAUDAL LENGTH (4x7)	CAUDAL DEPTH (4x9)
MIDDLE FORK SALMON	S	85	20.529	24.992	21.501	24.109	11.534	34.453	23.290
			[0.52]	[1.01]	[0.67]	[0.95]	[0.33]	[0.68]	[0.57]
EAST FK. SALMON R.	S	85	18.956	22.376	18.951	22.137	11.084	35.180	22.752
			[0.67]	[0.74]	[0.80]	[0.65]	[0.37]	[0.40]	[0.56]
VALLEY CREEK	SUM	85	20.928	25.154	21.012	25.524	11.154	35.072	22.872
			[0.74]	[0.82]	[0.73]	[0.44]	[0.56]	[0.58]	[0.37]
VALLEY CREEK	S	85	24.275	26.332	22.045	26.797	11.440	34.388	23.766
			[1.07]	[1.13]	[1.09]	[1.23]	[0.35]	[0.54]	[0.53]
SAWTOOTH STOCK	S	84	18.099	21.608	17.953	22.251	11.794	35.131	22.404
			[0.77]	[0.86]	[0.62]	[0.51]	[0.38]	[0.70]	[0.63]
YAKIMA RIVER	F	85	19.437	--	--	25.191	11.129	34.494	22.834
			[0.27]	--	--	[0.37]	[0.48]	[0.51]	[0.47]
YAKIMA RIVER	S	85	19.451	23.801	20.275	25.003	11.644	34.853	22.795
			[0.71]	[1.06]	[0.68]	[0.87]	[0.48]	[0.51]	[0.48]
NACHES RIVER	S	85	21.039	24.021	21.176	24.787	11.232	35.023	22.899
			[0.97]	[1.03]	[0.91]	[0.87]	[0.39]	[0.55]	[0.66]
HANFORD REACH	F	85	20.515	24.519	20.468	24.795	11.192	35.306	23.320
			[0.66]	[0.71]	[0.74]	[0.47]	[0.49]	[0.58]	[0.59]
PRIEST RAPIDS HATCHERY	F	84	--	--	--	--	11.500	35.845	23.679
			--	--	--	--	[0.83]	[0.62]	[0.50]
WENATCHEE RIVER	S	84	19.459	24.765	19.976	24.345	10.652	35.090	24.234
			[1.00]	[0.95]	[0.70]	[1.00]	[0.86]	[0.68]	[0.61]
WENATCHEE RIVER	SUM	85	20.097	23.840	20.490	25.191	11.703	35.909	23.776
			[0.75]	[0.92]	[0.82]	[0.85]	[0.45]	[0.80]	[0.51]
LEAVENWORTH HATCHERY	S	85	18.476	22.824	19.365	23.375	10.998	34.491	22.820
			[0.67]	[0.70]	[0.82]	[0.64]	[0.36]	[0.93]	[0.63]
ENTIAT RIVER	S	84	20.105	24.757	21.296	24.988	11.340	34.912	23.574
			[1.09]	[1.20]	[1.00]	[0.84]	[0.56]	[0.68]	[0.60]
WELLS DAM HATCHERY	SUM	84	--	--	--	--	11.633	36.500	23.723
			--	--	--	--	[0.68]	[0.70]	[0.68]
WELLS DAM HATCHERY	SUM	85	18.844	22.606	20.121	23.278	11.450	36.542	23.309
			[0.84]	[0.55]	[0.71]	[0.55]	[0.52]	[0.86]	[0.63]
METHOW RIVER	S	84	20.836	25.017	20.441	25.316	11.053	34.822	23.381
			[1.11]	[0.88]	[1.08]	[0.94]	[0.64]	[0.60]	[0.46]
METHOW RIVER	SUM	85	20.045	24.195	20.682	24.373	11.725	35.750	23.376
			[0.58]	[0.66]	[0.58]	[0.66]	[0.45]	[0.88]	[0.59]
WINTHROP HATCHERY	S	85	19.328	23.891	20.005	23.623	11.633	34.864	23.339
			[0.65]	[0.37]	[0.89]	[0.53]	[0.39]	[0.68]	[0.59]
OKANAGAN RIVER	SUM	84	18.583	23.638	20.173	23.280	11.274	36.009	24.514
			[0.46]	[0.59]	[0.93]	[0.51]	[0.70]	[0.80]	[0.38]
OKANAGAN RIVER	SUM	85	20.279	23.997	20.229	24.452	11.468	35.874	23.395
			[0.55]	[0.69]	[0.49]	[0.59]	[0.67]	[0.79]	[0.56]

Table A5. Chinook body shape characters (continued).

STOCK	FORM	YEAR	DEPTH CAUDAL PEDUNCLE (6x8)	PECTORAL FIN (13x14)	PELVIC FIN (11x12)	MAXILLARY LENGTH (1x17)	DORSAL FIN HEIGHT (18x19)	ANAL FIN HEIGHT (22x23)	ANAL FIN BASE (9x10)
COWLITZ HATCHERY	F	84	7.250	12.469	10.276	10.783	--	--	11.776
			[0.28]	[0.66]	[0.36]	[0.45]	--	--	[0.65]
COWLITZ HATCHERY	F	85	7.188	12.641	10.434	11.069	10.912	--	10.931
			[0.33]	[0.60]	[0.43]	[0.36]	[0.45]	--	[0.59]
COWLITZ HATCHERY	S	85	7.620	12.575	9.985	10.593	10.229	--	11.170
			[0.35]	[0.41]	[0.53]	[0.29]	[0.58]	--	[0.51]
KALAMA HATCHERY	F	84	7.131	12.781	10.043	9.899	8.546	7.957	11.360
			[0.29]	[0.57]	[0.41]	[0.37]	[0.51]	[0.48]	[0.67]
KALAMA HATCHERY	S	85	7.120	12.723	10.226	11.227	10.728	7.107	11.070
			[0.28]	[0.52]	[0.40]	[0.40]	[0.62]	[0.47]	[0.49]
LEWIS HATCHERY	S	85	7.343	12.860	10.949	11.291	10.886	7.956	11.280
			[0.30]	[0.52]	[0.44]	[0.42]	[0.88]	[0.53]	[0.42]
LEWIS HATCHERY	F	85	7.475	12.149	9.968	10.714	10.278	7.026	11.731
			[0.28]	[0.43]	[0.41]	[0.49]	[0.40]	[0.29]	[0.52]
LEWIS RIVER	F	85	6.723	13.049	10.643	11.115	11.244	7.026	12.012
			[0.31]	[0.56]	[0.70]	[0.47]	[0.77]	[0.42]	[0.43]
CLACKAMAS RIVER	F	85	7.059	13.666	10.603	11.298	11.223	7.563	11.818
			[0.42]	[0.81]	[0.80]	[0.36]	[0.84]	[0.53]	[0.55]
CLACKAMAS RIVER	S	84	7.160	14.615	11.517	11.786	12.762	8.250	12.835
			[0.41]	[0.68]	[0.61]	[0.43]	[0.98]	[1.06]	[0.33]
EAGLE CREEK HATCHERY	S	85	7.155	12.837	10.340	10.993	10.944	6.799	11.550
			[0.18]	[0.64]	[0.65]	[0.53]	[0.69]	[0.56]	[0.45]
MARION FORKS HATCHERY	S	85	7.867	12.312	10.388	10.296	10.192	8.368	12.160
			[0.31]	[0.62]	[0.67]	[0.33]	[0.50]	[0.79]	[0.52]
SOUTH SANTIAM HATCHERY	S	85	6.977	12.567	10.381	10.961	10.014	7.262	11.319
			[0.25]	[0.69]	[0.42]	[0.46]	[0.70]	[0.56]	[0.40]
THOMAS CREEK	S	83	6.892	14.087	11.518	11.858	12.945	8.683	11.818
			[0.25]	[0.49]	[0.52]	[0.23]	[0.69]	[0.75]	[0.60]
MCKENZIE HATCHERY	S	83	7.366	16.543	12.482	10.169	17.616	--	12.271
			[0.23]	[0.88]	[0.71]	[0.50]	[0.36]	--	[0.76]
MCKENZIE HATCHERY	S	85	7.136	12.756	10.462	10.670	8.908	6.714	10.627
			[0.26]	[0.65]	[0.65]	[0.58]	[0.57]	[0.35]	[0.45]
DEXTER HATCHERY	S	85	6.935	12.135	10.278	10.487	9.933	7.553	11.419
			[0.23]	[0.46]	[0.59]	[0.52]	[0.34]	[0.46]	[0.60]
SANDY RIVER	F	85	7.172	14.619	11.360	11.160	10.910	7.667	11.989
			[0.20]	[0.89]	[0.74]	[0.27]	[0.77]	[0.49]	[0.60]
WASHOUGAL RIVER	F	85	7.280	14.519	11.469	11.733	10.898	7.646	12.001
			[0.33]	[0.76]	[0.65]	[0.37]	[0.62]	[0.52]	[0.57]
BONNEVILLE HATCHERY	F	84	7.106	11.749	9.460	10.712	8.737	7.289	11.125
			[0.29]	[0.62]	[0.53]	[0.35]	[0.69]	[0.25]	[0.60]
CARSON HATCHERY	S	84	7.519	13.399	11.232	10.340	11.823	7.459	12.045
			[0.35]	[0.72]	[0.63]	[0.48]	[0.51]	[0.54]	[0.52]
CARSON HATCHERY	S	85	7.751	12.150	10.005	10.245	9.671	8.105	11.479
			[0.26]	[0.64]	[0.56]	[0.31]	[0.67]	[0.59]	[0.57]

Table A5. Chinook body shape characters (continued).

STOCK	FORM	YEAR	DEPTH CAUDAL PEDUNCLE (6x8)	PECTORAL FIN (13x14)	PELVIC FIN (11x12)	MAXILLARY LENGTH (1x17)	DORSAL FIN HEIGHT (18x19)	ANAL FIN HEIGHT (22x23)	ANAL FIN BASE (9x10)
LIT.WHITE SALMON HATCH.	S	83	7.194	12.810	10.857	9.987	11.891	9.127	11.248
			[0.36]	[0.67]	[0.37]	[0.74]	[0.80]	[0.64]	[0.43]
LIT.WHITE SALMON HATCH.	S	85	7.387	12.558	10.363	10.211	10.570	8.423	11.486
			[0.30]	[0.54]	[0.44]	[0.33]	[0.51]	[0.49]	[0.44]
SPRING CREEK HATCHERY	F	84	7.076	12.567	10.671	10.953	10.993	7.928	11.295
			[0.36]	[0.76]	[0.60]	[0.33]	[0.68]	[0.25]	[0.43]
KLICKITAT RIVER	F	85	7.084	14.012	11.132	11.469	11.542	7.274	11.312
			[0.30]	[0.75]	[0.74]	[0.32]	[0.57]	[0.39]	[0.97]
KLICKITAT HATCHERY	S	83	7.442	13.538	11.820	10.713	10.929	8.271	11.534
			[0.29]	[0.81]	[0.68]	[0.52]	[0.52]	[0.63]	[0.66]
KLICKITAT HATCHERY	S	85	6.918	12.489	10.365	10.594	10.792	7.239	11.344
			[0.33]	[0.60]	[0.55]	[0.49]	[0.38]	[0.33]	[0.60]
DESCHUTES RIVER	F	84	7.150	12.436	10.021	11.168	10.437	6.316	12.758
			[0.31]	[0.51]	[0.49]	[0.35]	[0.44]	[0.27]	[0.78]
ROUND BUTTE HATCHERY	S	85	7.378	12.509	10.217	9.941	10.487	9.098	12.448
			[0.20]	[0.49]	[0.49]	[0.42]	[0.74]	[0.46]	[0.68]
WARM SPRINGS RIVER	S	85	7.531	12.802	10.342	10.637	11.586	7.824	11.573
			[0.31]	[0.61]	[0.53]	[0.53]	[0.69]	[0.64]	[0.57]
JOHN DAY RIVER	S	84	7.419	13.890	11.129	10.790	12.370	9.474	12.372
			[0.31]	[0.82]	[0.70]	[0.37]	[1.05]	[0.43]	[0.73]
JOHN DAY RIVER	S	85	7.523	14.778	12.105	11.349	11.601	8.913	11.914
			[0.42]	[0.74]	[0.58]	[0.43]	[0.66]	[0.69]	[0.62]
SNAKE RIVER STOCK	F	84	6.604	11.085	10.817	12.271	9.808	6.067	10.643
			[0.23]	[0.70]	[0.51]	[0.63]	[0.48]	[0.47]	[0.44]
TUCANNON RIVER	S	84	7.322	15.452	13.537	11.200	12.963	10.694	11.668
			[0.37]	[0.87]	[0.79]	[0.46]	[1.09]	[0.98]	[0.70]
GRANDE RONDE RIVER	S	83	7.387	14.383	11.889	10.736	12.872	9.134	11.730
			[0.28]	[1.02]	[0.55]	[0.48]	[1.02]	[0.77]	[0.56]
GRANDE RONDE RIVER	S	84	7.050	16.154	12.083	11.716	15.320	--	12.500
			[0.33]	[1.40]	[1.08]	[0.83]	[1.90]	--	[0.46]
WALLOWA-LOSTINE RIVER	S	84	7.375	15.416	11.725	10.763	13.044	7.568	13.069
			[0.42]	[0.61]	[0.69]	[0.36]	[0.71]	[0.44]	[0.71]
RED R. SF CLEARWATER	S	85	7.103	13.980	11.119	10.276	11.503	7.988	10.986
			[0.20]	[0.56]	[0.65]	[0.38]	[0.48]	[0.51]	[0.56]
IMNAHA RIVER	S	84	7.834	15.599	12.569	10.730	--	--	12.522
			[0.40]	[0.89]	[0.54]	[0.36]		--	[0.81]
KOOSKIA HATCHERY STOCK	S	85	7.034	12.699	10.654	10.284	9.721	7.236	10.946
			[0.36]	[0.64]	[0.94]	[0.33]	[0.58]	[0.36]	[0.52]
RAPID RIVER HATCHERY	S	84	6.959	14.016	11.826	9.664	10.852	7.549	11.036
			[0.25]	[0.45]	[0.52]	[0.39]	[0.29]	[0.53]	[0.58]
JOHNSON CREEK	SUM	85	6.968	15.179	10.641	11.819	12.166	9.020	11.448
			[0.33]	[0.68]	[0.72]	[0.35]	[0.76]	[0.40]	[0.45]
McCALL HATCHERY	SUM	84	7.041	14.024	11.020	10.243	10.978	8.353	11.723
			[0.22]	[0.71]	[0.45]	[0.54]	[0.50]	[0.60]	[0.54]

Table A5. Chinook body shape characters (continued).

STOCK	FORM	YEAR	DEPTH CAUDAL PEDUNCLE (6x8)	PECTORAL FIN (13x14)	PELVIC FIN (11x12)	MAXILLARY LENGTH (1x17)	DORSAL FIN HEIGHT (18x19)	ANAL FIN HEIGHT (22x23)	ANAL FIN BASE (9x10)
MIDDLE FORK SALMON	S	85	7.494	15.246	11.701	11.185	13.864	9.046	11.894
			[0.41]	[0.79]	[0.63]	[0.35]	[0.81]	[0.78]	[0.53]
EAST FK. SALMON R.	S	85	6.867	13.433	10.110	10.404	10.905	7.501	10.781
			[0.24]	[0.50]	[0.56]	[0.32]	[0.49]	[0.49]	[0.40]
VALLEY CREEK	SUM	85	7.323	13.976	11.169	10.460	13.206	8.924	11.562
			[0.27]	[0.58]	[0.65]	[0.42]	[0.85]	[0.66]	[0.33]
VALLEY CREEK	S	85	7.533	15.288	12.189	11.273	12.319	9.887	11.399
			[0.25]	[0.94]	[0.72]	[0.49]	[0.94]	[0.67]	[0.52]
SAWTOOTH STOCK	S	84	7.104	14.159	11.054	10.101	10.949	7.953	10.178
			[0.21]	[0.43]	[0.44]	[0.47]	[0.57]	[0.34]	[0.40]
YAKIMA RIVER	F	85	7.110	12.659	9.742	11.956	14.642	6.668	11.335
			[0.32]	[0.41]	[0.51]	[0.39]	[0.49]	[0.63]	[0.46]
YAKIMA RIVER	S	85	7.482	14.594	11.365	11.701	12.447	7.795	11.479
			[0.41]	[0.66]	[0.54]	[0.56]	[0.79]	[0.53]	[0.44]
NACHES RIVER	S	85	6.866	13.727	10.792	11.007	12.061	8.403	11.532
			[0.24]	[0.55]	[0.46]	[0.33]	[1.02]	[0.65]	[0.50]
HANFORD REACH	F	85	7.108	14.011	11.197	11.842	10.912	7.796	11.676
			[0.25]	[0.76]	[0.60]	[0.40]	[0.86]	[0.42]	[0.56]
PRIEST RAPIDS HATCHERY	F	84	6.419	12.013	11.226	10.464	9.385	—	10.574
			[0.35]	[0.46]	[0.61]	[0.41]	[0.17]	—	[0.71]
WENATCHEE RIVER	S	84	7.433	15.209	11.819	11.322	13.073	8.109	12.413
			[0.44]	[1.03]	[0.73]	[0.44]	[0.52]	[0.37]	[0.87]
WENATCHEE RIVER	SUM	85	7.195	13.316	10.762	11.398	10.759	—	11.339
			[0.28]	[0.94]	[0.58]	[2.14]	[0.68]	—	[0.65]
LEAVENWORTH HATCHERY	S	85	7.153	12.962	10.482	10.571	10.241	7.724	11.905
			[0.23]	[0.52]	[0.48]	[0.34]	[0.48]	[0.37]	[0.47]
ENTIAT RIVER	S	84	7.606	14.865	11.887	10.969	13.596	9.056	12.327
			[0.39]	[0.70]	[0.80]	[0.39]	[0.85]	[0.64]	[0.73]
WELLS DAM HATCHERY	SUM	84	6.908	11.803	9.901	11.027	—	—	10.572
			[0.30]	[0.72]	[0.44]	[0.39]	—	—	[0.73]
WELLS DAM HATCHERY	SUM	85	6.887	11.804	9.805	10.999	10.744	7.280	10.527
			[0.27]	[0.54]	[0.48]	[0.29]	[0.47]	[0.50]	[0.38]
METHOW RIVER	S	84	7.317	14.806	11.590	12.352	12.965	8.310	12.221
			[0.40]	[0.79]	[0.63]	[2.14]	[0.69]	[0.70]	[0.47]
METHOW RIVER	SUM	85	7.091	13.212	10.245	10.871	10.452	7.071	11.466
			[0.31]	[0.66]	[0.65]	[0.50]	[0.32]	[0.44]	[0.61]
WINTHROP HATCHERY	S	85	7.751	12.765	10.237	10.830	10.214	7.821	11.171
			[0.34]	[0.79]	[0.60]	[0.55]	[0.47]	[0.37]	[0.46]
OKANAGAN RIVER	SUM	84	7.281	11.927	10.328	10.660	—	6.968	11.949
			[0.25]	[0.50]	[0.47]	[0.37]	—	[0.49]	[0.64]
OKANAGAN RIVER	SUM	85	6.873	13.412	10.545	10.757	10.680	7.033	11.259
			[0.32]	[0.69]	[0.45]	[0.39]	[0.67]	[0.53]	[0.69]

APPENDIX TABLE A6

Steelhead trout body shape character means and standard deviations. Standard deviations are in square parentheses. Numbers in round parentheses are landmark points on the body of the fish (see Figure 5 for key). "Year" indicates the year that the stock was sampled. "Form" indicates the time of freshwater entry (S for summer and W for winter).

Table A6. Steelhead body shape characters.

STOCK	FORM	YEAR	HEAD WIDTH	HEAD LENGTH (1x16)	HEAD DEPTH (2x15)	TOP OF HEAD TO INSERT. PECTORAL (2x14)	SNOUT TO TOP OF HEAD (1x2)	INTER-ORBITAL WIDTH
BIG CREEK HATCHERY	W	85	9.389	20.338	17.302	9.389	16.904	5.945
			[0.37]	[0.63]	[0.66]	[0.37]	[0.61]	[0.17]
GRAYS RIVER	W	85	10.073	23.358	17.025	10.073	18.033	5.927
			[0.33]	[0.66]	[0.54]	[0.33]	[0.71]	[0.20]
ELOCHOMAN HATCHERY	W	83	9.919	22.440	16.548	9.919	19.186	6.178
			[0.26]	[1.27]	[0.67]	[0.26]	[0.49]	[0.26]
COWLITZ HATCHERY NATIVE	W	84	9.434	21.142	17.581	9.434	17.829	6.081
			[0.30]	[0.93]	[0.60]	[0.30]	[0.51]	[0.21]
COWLITZ HATCHERY CHAMBERS	W	83	10.341	22.386	17.447	10.341	18.610	5.374
			[0.37]	[1.19]	[0.56]	[0.37]	[0.55]	[0.24]
COWLITZ HATCHERY SKAMANIA	S	83	9.312	22.519	17.022	9.312	18.016	5.918
			[0.33]	[1.45]	[0.69]	[0.33]	[0.58]	[0.22]
S.F. TOUTLE RIVER	W	85	9.954	23.067	17.507	9.954	18.582	5.760
			[0.66]	[0.95]	[0.79]	[0.66]	[0.96]	[0.30]
COWEEMAN RIVER	W	85	10.163	24.124	17.782	10.164	20.060	6.372
			[0.42]	[0.78]	[0.56]	[0.41]	[0.65]	[0.27]
EAGLE CREEK HATCH.(BIG CRK.)	W	85	9.110	19.921	16.209	9.110	15.945	5.578
			[0.42]	[0.89]	[0.44]	[0.42]	[0.39]	[0.14]
EAGLE CREEK HATCH.(NATIVE)	W	83	9.803	21.416	16.477	9.803	17.704	5.845
			[0.36]	[1.19]	[0.49]	[0.36]	[0.64]	[0.29]
MARION FORKS HATCHERY	W	85	9.907	20.549	17.097	9.908	17.219	5.774
			[0.36]	[0.77]	[0.48]	[0.36]	[0.55]	[0.20]
THOMAS CREEK	W	83	10.053	23.782	17.078	10.053	18.440	5.936
			[0.33]	[0.74]	[0.54]	[0.33]	[0.88]	[0.27]
THOMAS CREEK	W	85	9.839	23.301	17.386	9.839	18.371	5.885
			[0.38]	[0.77]	[0.61]	[0.38]	[0.61]	[0.19]
WILEY CREEK	W	84	10.192	23.376	17.745	10.192	18.718	6.002
			[0.40]	[0.88]	[0.71]	[0.40]	[0.65]	[0.32]
SOUTH SANTIAM HATCHERY	S	85	9.791	21.755	16.614	9.791	16.789	5.534
			[0.33]	[0.64]	[0.64]	[0.34]	[0.64]	[0.18]
CALAPOOYA RIVER	W	83	9.747	23.034	16.747	9.748	18.988	5.806
			[0.42]	[0.98]	[0.44]	[0.42]	[0.77]	[0.33]
LEABURG HATCHERY	S	85	9.675	20.134	17.191	9.675	16.499	5.769
			[0.45]	[0.91]	[0.64]	[0.45]	[0.69]	[0.17]
MCKENZIE RIVER	S	85	10.571	24.209	17.845	10.571	19.317	61.562
			[0.47]	[0.70]	[0.59]	[0.47]	[0.73]	[0.24]
SANDY RIVER	W	84	10.115	22.975	17.851	10.115	18.775	5.999
			[0.55]	[1.00]	[0.81]	[0.55]	[0.56]	[0.18]
WASHOUGAL HATCHERY	S	85	9.705	21.461	16.966	9.706	17.212	5.725
			[0.28]	[0.59]	[0.36]	[0.28]	[0.45]	[0.18]
WASHOUGAL HATCHERY	W	85	9.922	21.251	17.367	9.921	17.866	5.886
			[0.36]	[0.61]	[0.61]	[0.36]	[0.44]	[0.59]

Table A6. Steelhead body shape characters (continued).

STOCK	FORM	YEAR	HEAD WIDTH	HEAD LENGTH (1x16)	HEAD DEPTH (2x15)	TOP OF HEAD TO INSERT. PECTORAL (2x14)	SNOUT TO TOP OF HEAD (1x2)	INTER-ORBITAL WIDTH
HAMILTON CREEK	W	85	9.915	23.342	17.009	9.915	18.417	6.095
			[0.52]	[0.71]	[0.64]	[0.52]	[0.66]	[0.25]
WIND RIVER	S	85	9.694	23.123	17.040	9.694	18.393	5.978
			[0.34]	[0.72]	[0.68]	[0.34]	[0.51]	[0.20]
HOOD RIVER	W	85	10.267	23.364	17.764	10.267	17.909	5.864
			[0.31]	[0.72]	[0.37]	[0.31]	[0.64]	[0.29]
KLICKITAT RIVER	S	84	9.633	23.174	17.096	9.633	17.968	6.008
			[0.24]	[0.75]	[0.73]	[0.24]	[0.69]	[0.18]
FIFTEENMILE CREEK	W	83	9.670	23.537	17.319	9.670	18.970	5.924
			[0.29]	[0.98]	[0.64]	[0.29]	[0.82]	[0.31]
FIFTEENMILE CREEK	W	85	9.993	23.353	17.613	9.993	18.638	5.849
			[0.39]	[0.60]	[0.71]	[0.33]	[0.64]	[0.26]
DESCHUTES RIVER	S	84	10.173	23.752	17.696	10.173	18.176	6.232
			[0.31]	[0.88]	[0.65]	[0.31]	[0.84]	[0.26]
ROUND BUTTE HATCHERY	S	85	9.340	21.374	16.905	9.340	16.525	5.847
			[0.41]	[0.56]	[0.66]	[0.41]	[0.57]	[0.15]
JOHN DAY RIVER	S	84	10.013	23.587	17.533	10.013	18.762	6.056
			[0.45]	[0.77]	[0.69]	[0.45]	[0.75]	[0.27]
UMATILLA RIVER	S	83	9.783	23.578	17.012	9.783	18.749	5.855
			[0.33]	[0.83]	[0.46]	[0.33]	[0.57]	[0.24]
UMATILLA RIVER	S	84	9.871	23.655	17.215	9.871	18.444	6.198
			[0.34]	[0.77]	[0.68]	[0.34]	[0.59]	[0.23]
UMATILLA HATCHERY	S	85	9.542	21.277	16.660	9.542	17.288	5.833
			[0.42]	[0.55]	[0.40]	[0.42]	[0.33]	[0.18]
WALLA WALLA RIVER	S	85	9.712	23.514	17.379	9.712	18.778	5.936
			[0.32]	[0.69]	[0.57]	[0.32]	[0.57]	[0.16]
TOUCHET RIVER	S	85	9.962	24.340	17.547	9.962	18.902	6.091
			[0.48]	[0.47]	[0.78]	[0.48]	[0.53]	[0.21]
TUCANNON RIVER	S	84	9.675	23.224	17.229	9.675	17.853	5.950
			[0.18]	[0.80]	[0.44]	[0.18]	[0.69]	[0.20]
TUCANNON RIVER	S	85	9.704	23.463	17.104	9.704	18.407	5.890
			[0.28]	[0.95]	[0.67]	[0.28]	[0.50]	[0.22]
GRANDE RONDE RIVER	S	83	10.096	23.596	17.281	10.096	18.583	6.016
			[0.42]	[0.62]	[0.50]	[0.42]	[0.44]	[0.23]
GRANDE RONDE RIVER	S	84	10.262	24.272	17.517	10.262	18.780	6.311
			[0.35]	[0.87]	[0.60]	[0.35]	[0.82]	[0.23]
WALLOWA-LOSTINE	S	83	9.577	23.120	16.661	9.577	17.503	5.981
			[0.36]	[1.42]	[0.56]	[0.36]	[0.73]	[0.34]
WALLOWA-LOSTINE	S	85	9.558	23.059	17.182	9.558	18.320	5.919
			[0.33]	[0.60]	[0.50]	[0.33]	[0.60]	[0.15]
WALLOWA HATCHERY	S	84	9.609	21.898	17.618	9.609	17.866	5.682
			[0.30]	[1.10]	[0.56]	[0.30]	[0.47]	[0.16]
IMNAHA RIVER	S	83	9.797	23.805	17.035	9.797	18.421	5.973
			[0.42]	[1.20]	[0.75]	[0.42]	[0.98]	[0.28]

Table A6. Steelhead body shape characters (continued).

STOCK	FORM	YEAR	HEAD WIDTH	HEAD LENGTH (1x16)	HEAD DEPTH (2x15)	TOP OF HEAD TO INSERT. PECTORAL (2x14)	SNOUT TO TOP OF HEAD (1x2)	INTER-ORBITAL WIDTH
IMNAHA RIVER	S	84	9.917	23.361	17.488	9.917	18.491	6.085
			[0.28]	[0.70]	[0.58]	[0.28]	[0.76]	[0.24]
IMNAHA HATCHERY	S	84	9.708	21.518	17.517	9.708	17.664	5.592
			[0.33]	[1.05]	[0.59]	[0.33]	[0.61]	[0.24]
MISSION CREEK	S	85	9.850	22.931	17.468	9.850	18.343	5.977
			[0.30]	[0.73]	[0.67]	[0.30]	[0.45]	[0.21]
BIG CANYON/COTTONWOOD CRKS.	S	85	10.367	24.527	17.442	10.367	19.319	6.227
			[0.45]	[1.21]	[0.47]	[0.45]	[0.72]	[0.32]
DWORSHAK HATCHERY	S	85	8.797	21.570	17.572	8.797	16.963	5.367
			[0.57]	[0.81]	[0.59]	[0.57]	[0.53]	[0.41]
SELWAY RIVER	S	85	9.410	22.655	16.441	9.410	17.787	5.720
			[0.33]	[0.80]	[0.42]	[0.33]	[0.47]	[0.28]
LOCHSA RIVER	S	85	9.783	23.255	17.572	9.783	18.232	6.030
			[0.30]	[0.83]	[0.55]	[0.30]	[0.56]	[0.22]
SHEEP & BARGAMIN CRKS.	S	85	9.754	23.617	17.231	9.754	18.209	5.950
			[0.33]	[0.57]	[0.55]	[0.33]	[0.48]	[0.30]
S.F.SALMON (SECESH RIVER)	S	84	9.846	23.999	17.370	9.846	18.148	6.017
			[0.35]	[0.98]	[0.61]	[0.35]	[0.79]	[0.19]
S.F.SALMON (JOHNSON CREEK)	S	85	10.040	23.940	17.588	10.040	18.639	6.223
			[1.03]	[0.83]	[0.57]	[1.03]	[0.42]	[0.47]
CHAMBERLAIN CREEK	S	85	9.607	23.405	17.580	9.607	18.463	5.970
			[0.38]	[0.79]	[0.65]	[0.38]	[0.63]	[0.26]
HORSE CREEK	S	85	9.563	24.159	17.364	9.563	18.396	5.769
			[0.44]	[0.78]	[0.61]	[0.44]	[0.44]	[0.22]
MIDDLE FORK SALMON RIVER	S	85	9.790	23.910	17.368	9.790	18.831	6.296
			[0.49]	[0.79]	[0.45]	[0.49]	[0.47]	[0.26]
PAHSIMEROI 'B' STOCK	S	85	9.142	20.672	17.165	9.142	16.251	5.482
			[0.21]	[0.83]	[0.46]	[0.21]	[0.41]	[0.14]
SAWTOOTH 'A' STOCK	S	85	9.223	19.822	16.693	9.223	16.053	5.470
			[0.40]	[0.54]	[0.34]	[0.40]	[0.35]	[0.17]
HELLS CANYON STOCK	S	85	9.309	20.781	16.757	9.309	16.938	5.730
			[0.23]	[1.00]	[0.70]	[0.23]	[0.52]	[0.17]
YAKIMA RIVER 83	S	83	10.156	24.178	17.855	10.138	18.820	6.168
			[0.26]	[0.88]	[0.54]	[0.40]	[0.81]	[0.24]
YAKIMA RIVER 84	S	84	10.138	24.013	17.878	10.156	18.765	6.072
			[0.40]	[0.63]	[0.43]	[0.26]	[0.49]	[0.23]
WENATCHEE RIVER	S	85	10.564	23.961	18.920	10.564	19.570	6.339
			[0.52]	[1.00]	[0.87]	[0.52]	[0.58]	[0.31]
ENTIAT RIVER	S	84	9.645	23.196	17.708	9.645	18.606	6.043
			[0.31]	[0.56]	[0.58]	[0.31]	[0.44]	[0.23]
WELLS HATCHERY	S	85	9.697	22.764	16.621	9.697	17.515	6.098
			[0.45]	[0.34]	[0.42]	[0.45]	[0.33]	[0.21]
METHOW RIVER	S	84	9.293	21.339	16.742	9.293	17.337	5.865
			[0.37]	[0.80]	[0.52]	[0.37]	[0.62]	[0.17]

Table A6. Steelhead body shape characters (continued).

STOCK	FORM	YEAR	CAUDAL FIN (6x20)	CAUDAL FIN (6x21)	CAUDAL FIN (8x21)	CAUDAL FIN (8x20)	CAUDAL LENGTH (6x9)	CAUDAL LENGTH (4x7)	CAUDAL DEPTH (4x9)
BIG CREEK HATCHERY	W	85	19.472	23.556	19.208	24.110	14.417	38.512	24.734
			[0.80]	[0.70]	[0.86]	[0.89]	[0.55]	[0.96]	[0.65]
GRAYS RIVER	W	85	20.073	25.516	21.036	26.321	14.247	36.865	23.182
			[0.62]	[0.75]	[0.84]	[0.90]	[0.61]	[0.97]	[0.71]
ELOCHOMAN HATCHERY	W	83	--	--	--	--	13.978	35.142	22.500
			--	--	--	--	[0.48]	[0.54]	[0.65]
COWLITZ HATCHERY NATIVE	W	84	--		--	--	14.447	37.914	23.611
			--	--	--	--	[0.61]	[0.83]	[0.59]
COWLITZ HATCHERY CHAMBERS	W	83	--	25.977	26.940	--	12.789	37.438	23.874
			--	[0.60]	[0.82]	--	[0.43]	[0.82]	[0.72]
COWLITZ HATCHERY SKAMANIA	S	83	21.280	26.715	23.626	27.062	13.548	37.749	22.747
			[0.93]	[1.44]	[1.15]	[0.93]	[0.71]	[1.03]	[0.75]
S.F. TOUTLE RIVER	W	85	22.278	27.283	21.730	27.321	13.800	36.867	23.130
			[1.27]	[1.340	[1.28]	[1.36]	[0.76]	[1.29]	[0.18]
COWEEMAN RIVER	W	85	20.739	23.962	19.004	25.220	13.662	36.704	22.923
			[0.97]	[0.87]	[0.52]	[0.91]	[0.54]	[0.76]	[0.63]
EAGLE CREEK HATCH.(BIG CR)	W	85	17.417	22.642	17.724	22.687	14.197	38.188	23.734
			[0.69]	[0.43]	[0.67]	[0.78]	[0.73]	[0.72]	[0.69]
EAGLE CREEK HATCH.(NATIVE)	W	83	--	--	--	--	13.544	37.940	23.830
			--	--	--		[0.66]	[0.80]	[0.44]
MARION FORKS HATCHERY	W	85	--	--	--	--	15.385	37.685	23.382
			--	--	--	--	[0.32]	[0.66]	[0.47]
THOMAS CREEK	W	83	21.326	26.248	22.273	26.903	13.956	36.091	22.274
			[0.97]	[0.58]	[0.86]	[0.62]	[0.57]	[1.53]	[1.19]
THOMAS CREEK	W	85	21.221	26.064	21.379	26.694	13.997	36.893	23.015
			[0.79]	[0.88]	[1.00]	[0.84]	[0.40]	[0.78]	[0.54]
WILEY CREEK	W	84	20.559	26.037	20.250	26.639	14.219	37.078	23.557
			[0.92]	[0.54]	[1.06]	[0.89]	[0.48]	[0.88]	[0.58]
SOUTH SANTIAM HATCHERY	S	85	19.204	24.516	19.793	24.752	14.529	38.561	23.919
			[1.08]	[0.68]	[0.77]	[0.66]	[0.43]	[1.05]	[0.66]
CALAPOOYA RIVER	W	83	21.111	26.175	21.703	26.263	13.539	36.848	22.641
			[0.86]	[0.83]	[0.92]	[0.94]	[0.71]	[0.80]	[0.64]
LEABURG HATCHERY	S	85	19.126	24.471	19.751	24.220	14.638	37.803	24.100
			[0.81]	[0.86]	[0.87]	[1.14]	[0.58]	[0.87]	[0.78]
MCKENZIE RIVER	S	85	21.497	27.219	22.206	27.791	14.209	36.023	22.354
			[0.64]	[0.89]	[1.06]	[0.64]	[0.63]	[0.98]	[0.60]
SANDY RIVER	W	84	20.321	26.089	20.656	26.566	14.146	37.015	23.855
			[0.88]	[0.68]	[0.97]	[0.83]	[0.65]	[1.45]	[0.88]
WASHOUGAL HATCHERY	S	85	18.593	23.856	19.393	24.401	14.426	38.176	23.655
			[0.84]	[0.87]	[0.96]	[0.80]	[0.49]	[1.00]	[0.57]
WASHOUGAL HATCHERY	W	85	18.941	23.836	20.230	23.765	14.584	38.215	24.337
			[0.88]	[0.67]	[0.84]	[0.83]	[0.62]	[0.97]	[0.96]

Table A6. Steelhead body shape characters (continued).

STOCK	FORM	YEAR	CAUDAL FIN (6x20)	CAUDAL FIN (6x21)	CAUDAL FIN (8x21)	CAUDAL FIN (8x20)	CAUDAL LENGTH (6x9)	CAUDAL LENGTH (4x7)	CAUDAL DEPTH (4x9)
HAMILTON CREEK	W	85	20.405	25.077	21.187	26.154	14.216	36.577	22.655
			[1.17]	[1.06]	[0.93]	[0.78]	[0.61]	[1.01]	[0.73]
WIND RIVER	S	85	20.667	26.089	21.792	26.805	14.110	36.466	22.828
			[0.75]	[0.67]	[0.84]	[0.75]	[0.50]	[0.96]	[0.46]
HOOD RIVER	W	85	21.836	26.979	21.776	27.172	13.921	36.684	23.030
			[1.03]	[1.02]	[0.92]	[0.80]	[0.60]	[0.83]	[0.68]
KLICKITAT RIVER	S	84	20.334	26.726	20.721	26.202	14.033	36.985	23.687
			[0.69]	[0.65]	[0.69]	[0.89]	[0.70]	[1.00]	[0.73]
FIFTEENMILE CREEK	W	83	21.210	26.392	21.729	27.067	13.192	36.443	22.911
			[0.61]	[0.59]	[0.28]	[0.53]	[0.55]	[0.96]	[0.83]
FIFTEENMILE CREEK	W	85	21.183	26.837	21.578	26.583	13.648	35.976	22.549
			[1.08]	[1.23]	[0.95]	[0.89]	[0.53]	[0.90]	[0.69]
DESCHUTES RIVER	S	84	21.806	27.054	22.956	27.469	13.788	36.469	23.402
			[1.19]	[1.28]	[1.18]	[1.25]	[0.58]	[0.67]	[0.75]
ROUND BUTTE HATCHERY	S	85	18.667	22.657	18.679	23.830	14.074	36.794	23.305
			[0.98]	[0.71]	[0.79]	[0.61]	[0.55]	[0.70]	[0.52]
JOHN DAY RIVER	S	84	21.327	27.083	22.087	27.005	13.477	36.418	22.538
			[0.87]	[0.89]	[0.93]	[1.17]	[0.77]	[1.19]	[1.02]
UMATILLA RIVER	S	83	20.025	26.015	21.460	26.587	13.650	36.493	22.937
			[0.97]	[0.90]	[0.56]	[1.10]	[0.52]	[1.01]	[0.82]
UMATILLA RIVER	S	84	20.460	26.529	21.018	26.954	13.668	36.453	22.821
			[0.74]	[0.94]	[0.63]	[1.08]	[0.73]	[1.00]	[0.84]
UMATILLA HATCHERY	S	85	19.953	24.236	19.910	24.951	13.682	37.621	23.663
			[0.78]	[0.54]	[0.82]	[0.87]	[0.54]	[1.02]	[0.88]
WALLA WALLA RIVER	S	85	21.950	26.725	22.880	27.252	13.781	36.359	22.643
			[0.83]	[0.73]	[0.78]	[0.60]	[0.63]	[0.63]	[0.60]
TOUCHET RIVER	S	85	21.950	26.238	22.569	26.496	13.372	36.605	22.655
			[1.08]	[0.85]	[1.00]	[0.80]	[0.56]	[1.12]	[0.82]
TUCANNON RIVER	S	84	21.082	26.134	21.520	26.399	13.382	37.227	23.294
			[0.70]	[0.48]	[0.58]	[0.76]	[0.59]	[0.40]	[0.49]
TUCANNON RIVER	S	85	21.538	25.755	21.874	26.192	13.414	36.617	22.784
			[0.98]	[1.04]	[0.97]	[0.77]	[0.66]	[0.84]	[0.64]
GRANDE RONDE RIVER	S	83	22.719	28.585	23.054	28.699	13.592	36.953	23.373
			[0.90]	[1.23]	[0.97]	[0.96]	[0.67]	[0.53]	[0.74]
GRANDE RONDE RIVER	S	84	21.407	26.738	22.477	27.324	13.265	36.217	22.941
			[0.86]	[0.95]	[0.79]	[0.40]	[0.95]	[1.21]	[0.79]
WALLOWA-LOSTINE	S	83	20.643	24.439	21.947	21.360	13.140	37.254	24.153
			[1.34]	[0.99]	[1.04]	[1.19]	[0.68]	[1.10]	[0.85]
WALLOWA-LOSTINE	S	85	20.122	25.324	19.838	25.072	13.713	36.993	23.733
			[0.99]	[0.65]	[0.75]	[0.97]	[0.72]	[1.06]	[0.83]
WALLOWA HATCHERY	S	84	19.098	23.516	19.623	24.756	13.978	36.824	23.548
			[0.99]	[1.11]	[0.60]	[0.97]	[0.70]	[0.94]	[0.85]
IMNAHA RIVER	S	83	20.727	26.190	21.239	26.600	13.360	35.835	22.415
			[1.09]	[0.83]	[1.19]	[0.96]	[0.51]	[0.95]	[0.56]

Table A6. Steelhead body shape characters (continued).

STOCK	FORM	YEAR	CAUDAL FIN (6x20)	CAUDAL FIN (6x21)	CAUDAL FIN (8x21)	CAUDAL FIN (8x20)	CAUDAL LENGTH (6x9)	CAUDAL LENGTH (4x7)	CAUDAL DEPTH (4x9)
IMNAHA RIVER	S	84	20.973	27.062	22.407	27.392	13.721	36.738	23.256
			[0.86]	[0.88]	[0.88]	[0.95]	[0.73]	[1.04]	[0.53]
IMNAHA HATCHERY	S	84	18.707	24.285	18.950	25.017	14.078	37.186	23.574
			[0.98]	[0.90]	[0.57]	[0.69]	[0.92]	[0.69]	[0.59]
MISSION CREEK	S	85	22.342	27.772	22.188	27.856	13.592	35.934	22.186
			[0.92]	[0.99]	[1.00]	[0.78]	[0.59]	[0.79]	[0.56]
BIG CANYON/COTTONWOOD CRKS.	S	85	22.661	27.467	22.998	28.403	13.858	35.536	22.021
			[0.85]	[0.97]	[0.97]	[0.74]	[0.65]	[1.15]	[0.64]
DWORSHAK HATCHERY	S	85	18.784	23.638	19.183	24.810	13.930	37.353	22.988
			[0.81]	[0.95]	[0.72]	[0.91]	[0.50]	[0.80]	[0.73]
SELWAY RIVER	S	85	21.735	26.091	21.619	26.575	13.917	36.714	23.128
			[0.86]	[1.02]	[0.52]	[0.93]	[0.49]	[0.56]	[0.48]
LOCHSA RIVER	S	85	22.283	27.265	22.155	27.540	14.151	36.427	22.492
			[0.92]	[0.91]	[0.54]	[0.76]	[0.46]	[1.19]	[0.77]
SHEEP & BARGAMIN CRKS.	S	85	22.651	28.400	23.141	28.514	13.997	36.232	22.757
			[0.46]	[0.62]	[0.67]	[0.51]	[0.75]	[0.75]	[0.54]
S.F.SALMON (SECESH RIVER)	S	84	21.676	26.972	21.917	27.115	13.676	36.747	23.570
			[0.73]	[0.55]	[0.84]	[0.69]	[0.42]	[1.02]	[0.91]
S.F.SALMON (JOHNSON CREEK)	S	85	--	26.033	22.388	--	14.043	37.020	23.451
			--	[0.36]	[0.22]	--	[0.37]	[0.88]	[0.69]
CHAMBERLAIN CREEK	S	85	23.718	28.565	23.433	28.322	13.942	37.156	23.624
			[0.46]	[1.17]	[0.65]	[0.94]	[0.71]	[0.88]	[0.53]
HORSE CREEK	S	85	22.520	28.672	24.134	27.949	14.313	37.416	23.372
			[0.62]	[1.26]	[0.96]	[0.90]	[0.59]	[0.63]	[0.53]
MIDDLE FORK SALMON RIVER	S	85	22.634	28.362	23.201	28.396	14.062	36.295	22.576
			[0.87]	[0.87]	[1.38]	[2.01]	[0.73]	[0.80]	[0.70]
PAHSIMEROI 'B' STOCK	S	85	18.854	24.043	19.555	24.711	14.078	38.409	24.694
			[0.58]	[0.77]	[0.84]	[0.74]	[0.53]	[0.74]	[0.74]
SAWTOOTH 'A' STOCK	S	85	18.571	23.307	19.410	23.905	14.288	38.412	24.712
			[0.65]	[0.86]	[0.73]	[0.74]	[0.56]	[0.82]	[1.89]
HELLS CANYON STOCK	S	85	18.514	22.798	19.425	24.238	14.066	37.953	23.527
			[0.79]	[0.64]	[0.80]	[0.74]	[0.45]	[1.31]	[0.96]
YAKIMA RIVER 83	S	83	22.002	27.873	22.827	28.239	14.021	36.312	23.079
			[0.82]	[1.04]	[0.98]	[1.11]	[0.67]	[1.00]	[0.76]
YAKIMA RIVER 84	S	84	21.746	27.900	21.997	27.891	14.112	35.754	22.513
			[1.25]	[1.11]	[1.12]	[1.23]	[0.59]	[0.70]	[0.37]
WENATCHEE RIVER	S	85	20.765	24.411	20.661	24.857	13.773	36.429	23.325
			[1.14]	[0.80]	[0.79]	[0.82]	[0.53]	[0.88]	[0.79]
ENTIAT RIVER	S	84	21.145	27.462	21.662	27.432	13.579	36.695	23.495
			[0.98]	[0.87]	[0.74]	[0.73]	[0.57]	[0.64]	[0.70]
WELLS HATCHERY	S	85	21.074	25.332	19.986	25.385	12.857	37.694	23.584
			0.49]	[0.76]	[0.68]	[0.65]	[0.42]	[0.71]	[0.66]
METHOW RIVER	S	84	22.280	27.365	21.517	27.599	13.905	36.498	23.138
			[1.44]	[1.31]	[0.70]	[1.45]	[0.92]	[1.18]	[0.91]

Table A6. Steelhead body shape characters (continued).

STOCK	FORM	YEAR	DEPTH CAUDAL PEDUNCLE (6x8)	PECTORAL FIN (13x14)	PELVIC FIN (11x12)	MAXILLARY LENGTH (1x17)	DORSAL FIN HEIGHT (18x19)	ANAL FIN HEIGHT (22x23)	ANAL FIN BASE (9x10)
BIG CREEK HATCHERY	W	85	9.505	13.722	12.103	9.398	--	9.634	9.725
			[0.28]	[0.79]	[0.23]	[0.34]	--	[0.68]	[0.49]
GRAYS RIVER	W	85	9.587	15.227	12.192	10.787	12.133	10.522	9.282
			[0.44]	[0.66]	[0.87]	[0.47]	[0.67]	[0.42]	[0.66]
ELOCHOMAN HATCHERY	W	83	8.686	17.050	13.221	11.747	--	--	9.357
			[0.36]	[0.75]	[0.78]	[0.76]	--	--	[0.45]
COWLITZ HATCHERY NATIVE	W	84	9.491	14.696	12.125	9.692	--	9.678	9.096
			[0.35]	[0.68]	[0.89]	[0.60]	--	[0.39]	[0.51]
COWLITZ HATCHERY CHAMBERS	W	83	9.351	16.370	13.521	9.562	--	8.768	9.864
			[0.31]	[0.71]	[0.57]	[0.57]	--	[0.62]	[0.41]
COWLITZ HATCHERY SKAMANIA	S	83	9.310	16.499	13.475	10.253		11.460	8.524
			[0.37]	[0.85]	[0.77]	[0.67]	--	[0.55]	[0.54]
S.F. TOUTLE RIVER	W	85	9.798	15.561	12.650	10.939	12.312	10.454	9.431
			[0.47]	[1.07]	[1.04]	[0.62]	[0.96]	[0.96]	[0.52]
COWEEMAN RIVER	W	85	9.107	15.444	11.753	11.226	11.392	10.601	9.349
			[0.37]	[0.78]	[0.65]	[0.45]	[0.52]	[0.53]	[0.57]
EAGLE CREEK HATCH.(BIG CR)	W	85	8.731	12.471	11.409	9.116	--	9.314	9.305
			[0.35]	[0.89]	[0.72]	[0.32]	--	[0.55]	[0.39]
EAGLE CREEK HATCH.(NATIVE)	W	83	9.176	13.701	12.240	9.914	--	8.094	8.760
			[0.38]	[0.86]	[0.86]	[0.56]	--	[0.55]	[0.58]
MARION FORKS HATCHERY	W	85	9.326	11.979	11.288	9.129	--	9.791	8.860
			[0.32]	[0.82]	[0.59]	[0.42]	--	[0.36]	[0.65]
THOMAS CREEK	W	83	9.410	16.561	13.189	11.350	12.701	10.744	8.919
			[0.33]	[0.82]	[0.80]	[0.67]	[0.20]	[0.68]	[0.44]
THOMAS CREEK	W	85	9.345	16.589	13.488	11.034	12.641	10.897	9.244
			[0.40]	[0.60]	[0.59]	[0.55]	[0.73]	[0.54]	[0.58]
WILEY CREEK	W	84	9.639	16.861	13.471	11.499	12.611	10.686	9.395
			[0.52]	[0.70]	[0.56]	[0.54]	[0.48]	[0.47]	[0.52]
SOUTH SANTIAM HATCHERY	S	85	9.328	13.833	12.148	9.730	--	8.415	8.155
			[0.34]	[0.67]	[0.62]	[0.39]	--	[0.53]	[0.63]
CALAPOOYA RIVER	W	83	8.838	16.283	13.434	10.835	11.982	10.518	9.008
			[0.43]	[0.90]	[0.65]	[0.76]	[0.82]	[0.61]	[0.61]
LEABURG HATCHERY	S	85	9.515	14.236	11.963	9.378	--	9.515	9.099
			[0.44]	[0.62]	[0.78]	[0.55]	--	[0.34]	[0.29]
MCKENZIE RIVER	S	85	9.795	16.681	12.890	11.399	12.288	10.766	9.180
			[0.35]	[0.70]	[0.89]	[0.50]	[0.82]	[0.84]	[0.65]
SANDY RIVER	W	84	9.676	16.073	12.539	10.675	11.840	10.076	9.738
			[0.39]	[0.58]	[0.79]	[0.77]	[0.73]	[0.62]	[0.64]
WASHOUGAL HATCHERY	S	85	9.293	13.986	11.708	9.742	--	8.537	8.769
			[0.24]	[0.54]	[0.65]	[0.50]	--	[0.29]	[0.58]
WASHOUGAL HATCHERY	W	85	9.419	12.814	11.138	9.558	--	8.866	9.341
			[0.36]	[0.78]	[0.69]	[0.46]	--	[0.43]	[0.77]

Table A6. Steelhead body shape characters (continued).

STOCK	FORM	YEAR	DEPTH CAUDAL PEDUNCLE (6x8)	PECTORAL FIN (13x14)	PELVIC FIN (11x12)	MAXILLARY LENGTH (1x17)	DORSAL FIN HEIGHT (18x19)	ANAL FIN HEIGHT (22x23)	ANAL FIN BASE (9x10)
HAMILTON CREEK	W	85	9.569	16.178	12.834	11.245	11.976	10.402	9.522
			[0.42]	[0.77]	[0.76]	[0.48]	[0.81]	[0.80]	[0.62]
WIND RIVER	S	85	9.375	16.040	12.525	10.634	12.594	10.541	9.323
			[0.41]	[0.78]	[0.70]	[0.43]	[0.63]	[0.48]	[0.53]
HOOD RIVER	W	85	9.645	16.705	13.254	10.884	12.457	10.657	9.239
			[0.39]	[0.73]	[0.71]	[0.65]	[0.64]	[0.78]	[0.49]
KLICKITAT RIVER	S	84	9.506	15.981	12.837	10.669	12.147	10.744	9.389
			[0.34]	[0.70]	[0.95	[0.47]	[0.79]	[0.44]	[0.62]
FIFTEENMILE CREEK	W	83	8.919	16.310	13.219	11.290	12.235	10.661	9.446
			[0.44]	[1.10]	[0.80]	[0.57]	[0.68]	[1.09]	[0.45]
FIFTEENMILE CREEK	W	85	9.208	16.068	12.563	11.075	12.194	10.163	9.135
			[0.35]	[0.80]	[0.75]	[0.61]	[0.75]	[0.81]	[0.57]
DESCHUTES RIVER	S	84	9.878	16.746	13.498	11.266	13.392	12.424	9.502
			[0.41]	[0.87]	[0.77]	[0.56]	[0.73]	[0.38]	[0.62]
ROUND BUTTE HATCHERY	S	85	9.167	13.385	11.296	9.290	9.396	9.023	9.232
			[0.38]	[0.71]	[0.73]	[0.41]	[0.45]	[0.59]	[0.41]
JOHN DAY RIVER	S	84	9.155	16.540	13.490	11.079	12.557	10.820	9.143
			[0.64]	[0.99]	[0.75]	[0.66]	[0.56]	[0.90]	[0.66]
UMATILLA RIVER	S	83	9.291	16.800	13.738	11.119	12.464	10.687	9.316
			[0.40]	[0.79]	[0.81]	[0.68]	[0.71]	[0.91]	[0.55]
UMATILLA RIVER	S	84	9.427	16.448	13.088	11.131	12.665	11.063	9.500
			[0.48]	[1.00]	[0.91]	[0.52]	[0.56]	[0.57]	[0.60]
UMATILLA HATCHERY	S	85	9.073	19.941	12.533	10.060	--	9.599	8.931
			[0.22]	[0.41]	[0.51]	[0.56]	--	[0.37]	[0.43]
WALLA WALLA RIVER	S	85	9.238	16.920	13.135	10.966	12.764	11.318	9.149
			[0.50]	[0.80]	[0.65]	[0.61]	[0.83]	[0.60]	[0.38]
TOUCHET RIVER	S	85	9.031	16.837	13.348	11.516	12.746	11.128	9.138
			[0.50]	[0.97]	[0.74]	[0.37]	[1.01]	[0.69]	[0.48]
TUCANNON RIVER	S	84	9.015	15.713	13.088	10.702	12.283	10.307	9.722
			[0.40]	[0.72]	[0.62]	[0.86]	[0.34]	[0.41]	[0.55]
TUCANNON RIVER	S	85	8.946	16.007	12.542	10.801	12.044	10.231	9.156
			[0.41]	[0.77]	[0.69]	[0.69]	[0.57]	[0.67]	[0.58]
GRANDE RONDE RIVER	S	83	9.268	17.145	13.855	11.505	13.271	11.698	9.382
			[0.47]	[0.99]	[0.80]	[0.65]	[0.59]	[0.87]	[0.35]
GRANDE RONDE RIVER	S	84	9.453	17.549	14.031	11.666	13.302	11.666	9.925
			[0.38]	[0.85]	[0.57]	[0.63]	[0.77]	[0.51]	[0.60]
WALLOWA-LOSTINE	S	83	8.963	21.947	16.842	10.527	12.782	12.609	9.704
			[0.47]	[0.96]	[0.63]	[0.60]	[0.54]	[0.51]	[0.40]
WALLOWA-LOSTINE	S	85	9.190	15.484	12.735	10.329	12.811	10.668	9.590
			[0.50]	[0.71]	[0.58]	[0.41]	[0.83]	[0.31]	[0.56]
WALLOWA HATCHERY	S	84	9.574	13.589	12.081	9.790	--	9.658	9.203
			[0.37]	[0.53]	[0.73]	[0.45]	--	[0.56]	[0.65]
IMNAHA RIVER	S	83	9.138	16.565	13.755	11.159	12.672	11.484	9.299
			[0.50]	[1.06]	[0.54]	[0.86]	[0.61]	[0.75]	[0.68]

Table A6. Steelhead body shape characters (continued).

STOCK	FORM	YEAR	DEPTH CAUDAL PEDUNCLE (6x8)	PECTORAL FIN (13x14)	PELVIC FIN (11x12)	MAXILLARY LENGTH (1x17)	DORSAL FIN HEIGHT (18x19)	ANAL FIN HEIGHT (22x23)	ANAL FIN BASE (9x10)
IMNAHA RIVER	S	84	9.393	16.891	13.738	10.944	13.115	11.465	9.697
			[0.52]	[0.94]	[0.60]	[0.60]	[0.54]	[0.51]	[0.40]
IMNAHA HATCHERY	S	84	9.339	13.886	12.841	9.904	--	9.828	9.289
			[0.39]	[0.63]	[0.59]	[0.71]	--	[0.58]	[0.54]
MISSION CREEK	S	85	9.460	16.621	12.606	10.728	13.120	10.898	8.806
			[0.37]	[0.70]	[0.90]	[0.40]	[0.53]	[0.57]	[0.49]
BIG CANYON/COTTONWOOD CRKS	S	85	9.627	16.873	12.967	11.825	13.735	12.203	9.187
			[0.53]	[0.78]	[0.65]	[0.81]	[0.61]	[0.59]	[0.53]
DWORSHAK HATCHERY	S	85	8.763	13.660	11.003	9.508	--	8.710	8.755
			[0.32]	[0.51]	[0.84]	[0.53]	--	[0.42]	[0.61]
SELWAY RIVER	S	85	9.147	15.966	12.484	10.459	12.987	10.797	9.176
			[0.35]	[0.94]	[0.85]	[0.45]	[0.74]	[0.56]	[0.68]
LOCHSA RIVER	S	85	9.325	16.650	12.963	10.949	12.690	10.546	9.047
			[0.37]	[0.78]	[0.50]	[0.64]	[0.67]	[0.50]	[0.59]
SHEEP & BARGAMIN CRKS.	S	85	9.368	16.988	13.064	10.957	13.348	11.686	9.263
			[0.46]	[0.88]	[0.60]	[0.44]	[0.74]	[0.60]	[0.51]
S.F.SALMON (SECESH RIVER)	S	84	9.187	16.942	12.969	11.196	12.366	10.193	9.146
			[9.19]	[0.71]	[0.76]	[0.55]	[0.72]	[0.48]	[0.47]
S.F.SALMON (JOHNSON CREEK)	S	85	9.446	17.640	13.301	10.866	12.519	11.139	9.179
			[0.26]	[0.92]	[0.63]	[0.67]	[0.81]	[0.69]	[0.55]
CHAMBERLAIN CREEK	S	85	9.539	17.170	13.592	10.959	13.252	10.795	9.599
			[0.40]	[0.68]	[0.58]	[0.60]	[0.44]	[0.63]	[0.58]
HORSE CREEK	S	85	9.589	17.539	13.019	11.852	12.789	11.054	9.058
			[0.46]	[0.65]	[1.09]	[0.37]	[0.77]	[0.42]	[0.65]
MIDDLE FORK SALMON RIVER	S	85	9.383	17.351	13.641	10.980	13.856	12.011	9.165
			[0.33]	[0.87]	[0.75]	[0.53]	[0.88]	[0.44]	[0.46]
PAHSIMEROI 'B' STOCK	S	85	8.837	13.506	10.841	9.676	--	9.480	8.371
			[0.37]	[0.58]	[0.72]	[0.44]	--	[0.49]	[0.55]
SAWTOOTH 'A' STOCK	S	85	9.015	13.467	10.665	8.840	--	9.688	8.272
			[0.40]	[0.66]	[0.79]	[0.43]	--	[0.65]	[0.66]
HELLS CANYON STOCK	S	85	8.785	13.894	12.041	9.481	--	9.318	8.358
			[0.26]	[0.87]	[0.54]	[0.62]	--	[0.60]	[0.32]
YAKIMA RIVER 83	S	83	9.708	16.318	14.197	11.380	13.238	11.940	9.559
			[0.54]	[1.20]	[0.44]	[0.57]	[0.79]	[0.64]	[0.36]
YAKIMA RIVER 84	S	84	9.905	16.866	13.839	11.779	13.276	11.447	9.312
			[0.27]	[0.90]	[0.57]	[0.60]	[0.59]	[0.69]	[0.60]
WENATCHEE RIVER	S	85	9.206	16.040	12.582	10.985	11.832	10.425	9.080
			[0.46]	[0.51]	[0.72]	[0.62]	[0.42]	[0.95]	[0.36]
ENTIAT RIVER	S	84	9.499	16.650	13.340	10.671	12.868	10.748	9.696
			[0.37]	[0.79]	[0.69]	[0.49]	[0.68]	[0.69]	[0.46]
WELLS HATCHERY	S	85	8.695	15.182	12.578	10.560	--	10.227	9.109
			[0.27]	[0.68]	[0.47]	[0.33]	--	[0.41]	[0.63]
METHOW RIVER	S	84	9.539	15.835	12.888	9.795	12.720	10.721	9.424
			[0.34]	[0.87]	[0.68]	[0.42]	[0.69]	[0.43]	[0.65]

APPENDIX TABLE A7

Estimated peak entry dates into the mouth of the Columbia River and peak spawning dates for chinook salmon. Estimated dates are stratified into two-week segments. "FORM" indicates season of freshwater entry (S for spring, F for fall and SUM for summer).

Table A7. Chinook life history characters.

STOCK	FORM	ESTIMATED PEAK ENTRY	PEAK SPAWNING
COWLITZ HATCHERY	F	SEP 15	NOV 1
COWLITZ HATCHERY	S	JUN 1	SEP 15
KALAMA HATCHERY	F	SEP 15	OCT 15
KALAMA HATCHERY	S	JUN 1	SEP 15
LEWIS HATCHERY	S	JUN 1	SEP 1
LEWIS HATCHERY	F	SEP 15	OCT 15
LEWIS RIVER	F	OCT 1	NOV 15
CLACKAMAS RIVER	F	SEP 1	SEP 15
CLACKAMAS RIVER	S	APR 1	OCT 1
EAGLE CREEK HATCHERY	S	APR 1	OCT 1
MARION FORKS HATCHERY	S	APR 1	OCT 1
SOUTH SANTIAM HATCHERY	S	APR 1	OCT 1
THOMAS CREEK	S	APR 1	OCT 1
MCKENZIE HATCHERY	S	APR 1	OCT 1
DEXTER HATCHERY	S	APR 1	OCT 1
SANDYRIVER	F	SEP 15	OCT 1
WASHOUGAL RIVER	F	SEP 15	OCT 1
BONNEVILLE HATCHERY	F	SEP 15	DEC 1
CARSON HATCHERY	S	APR 15	AUG 15
LIT.WHITE SALMON HATCH.	S	APR 15	AUG 15
SPRING CREEK HATCHERY	F	SEP 1	SEP 15
KLICKITAT RIVER	F	SEP 1	OCT 1
KLICKITAT HATCHERY	S	APR 1	SEP 1
DESCHUTES RIVER	F	JUL l	NOV 15
ROUND BUTTE HATCHERY	S	APR 15	SEP 1
WARM SPRINGS RIVER	S	APR 15	SEP 15
JOHN DAY RIVER	S	APR 15	SEP 1
SNAKE RIVER STOCK	F	SEP 1	NOV 1

Table A7. Chinook life history characters (continued).

STOCK	FORM	ESTIMATED PEAK ENTRY	PEAK SPAWNING
TUCANNON RIVER	S	APR 1	SEP 15
GRANDE RONDE RIVER	S	MAY 1	SEP 1
WALLOWA-LOSTINE RIVER	S	MAY 1	SEP 1
KOOSKIA HATCHERY STOCK	S	APR 15	SEP 1
RED R. SF CLEARWATER	S	MAR 15	AUG 15
IMNAHA RIVER	S	JUL 1	SEP 1
RAPID RIVER HATCHERY	S	MAR 15	SEP 1
JOHNSON CREEK	SUM	JUN 1	SEP 1
MCCALL HATCHERY	SUM	JUN 1	SEP 1
MIDDLE FORK SALMON	S	JUN 1	SEP 1
EAST FK. SALMON R. STOCK	S	APR 15	SEP 1
VALLEY CREEK	SUM	JUN l	SEP 15
VALLEY CREEK	S	APR 15	SEP 1
SAWTOOTH STOCK	S	APR 15	SEP 1
YAKIMA RIVER	F	SEP 1	NOV 15
YAKIMA RIVER	S	MAY 1	NOV 1
NACHES RIVER	S	MAY 1	SEP 1
HANFORD REACH	F	SEP 1	NOV 15
PRIEST RAPIDS HATCHERY	F	SEP 1	NOV 15
WENATCHEE RIVER	S	MAY 1	SEP 1
WENATCHEE RIVER	SUM	JUL 1	SEP 1
LEAVENWORTH HATCHERY	S	APR 15	SEP 1
ENTIAT RIVER	S	MAY 1	SEP 1
WELLS DAMHATCHERY	SUM	JUN 1	NOV 1
METHOW RIVER	S	APR 15	SEP 1
METHOW RIVER	SUM	JUL 1	NOV 1
WINTHROP HATCHERY	S	APR 15	SEP 1
OKANAGAN RIVER	SUM	JUL 1	NOV 1

APPENDIX TABLE A8

Estimated peak entry dates into the mouth of the Columbia River, peak spawning dates and ocean age for steelhead trout. Estimated dates are stratified into two-week segments. "FORM" indicates season of freshwater entry (S for summer and W for winter).

Table A8. Steelhead life history characters (continued).

STOCK	FORM	PEAK ENTRY	PEAK SPAWNING	OCEAN AGE
UMATILLA HATCHERY	S	JUL 15	APR 15	1.5
WALLA WALLA RIVER	S	JUL 15	MAY 1	1.4
TOUCHET RIVER	S	JUL 15	MAY 1	1.4
TUCANNON RIVER	S	AUG 1	MAY 1	1.4
GRANDE RONDE RIVER	S	JUL 15	APR 15	1
WALLOWA-LOSTINE	S	AUG 1	MAY 1	1
WALLOWA HATCHERY	S	AUG 1	APR 1	1
MISSION CREEK	S	AUG 1	APR 15	1
BIG CANYON/COTTONWOOD CRKS.	S	AUG 1	APR 15	1
DWORSHAK HATCHERY	S	SEP 1	APR 15	2
SELWAY RIVER	S	AUG 1	MAY 1	2
LOCHSA RIVER	S	AUG 1	MAY 1	2
IMNAHA RIVER	S	AUG 1	MAY 1	1
IMNAHA HATCHERY	S	AUG 1	MAY 1	1
SHEEP & BARGAMIN CRKS.	S	AUG 1	MAY 1	1
S.F.SALMON (SECESH RIVER)	S	SEP 15	MAY 1	2
S.F.SALMON (JOHNSON CREEK)	S	SEP 15	MAY 1	2
CHAMBERLAIN CREEK	S	AUG 1	MAY 1	1
HORSE CREEK	S	AUG 1	MAY 1	1
MIDDLE FORK SALMON RIVER	S	SEP 15	MAY 1	2
PAHSIMEROI 'B' STOCK	S	SEP 15	APR 1	1.5
SAWTOOTH 'A' STOCK	S	AUG 1	APR 1	1.5
HELLS CANYON STOCK	S	AUG 1	APR 1	1.5
YAKIMA RIVER	S	JUL 15	APR 15	1.5
WENATCHEE RIVER	S	JUL 15	MAY 1	1
ENTIAT RIVER	S	JUL 15	MAY 1	1
WELLS HATCHERY	S	JUL 15	FEB 1	1.5
METHOW RIVER	S	JUL 15	MAY 1	1

Table A8. Steelhead life history characters.

STOCK	FORM	PEAK ENTRY	PEAK SPAWNING	OCEAN AGE
BIG CREEK HATCHERY	W	JAN 1	JAN 15	2
GRAYS RIVER	W	MAR 15	MAY 1	2
ELOCHOMAN HATCHERY	W	DEC 15	JAN 15	2
COWLITZ HATCHERY NATIVE	W	JAN 1	JAN 15	2
COWLITZ HATCHERY CHAMBERS	W	JAN 1	JAN 15	2
COWLITZ HATCHERY SKAMANIA	S	MAR 15	JAN 15	2
S.F. TOUTLE RIVER	W	APR 1	MAY 1	2
COWEEMAN RIVER	W	MAR 15	MAY 1	2
EAGLE CREEK HATCHERY	W	FEB 1	MAR1	2
EAGLE CR. HATCH. (BIG CR.STK)	W	JAN 1	FEB 1	2
MARION FORKS HATCHERY	W	MAR 15	MAY 1	2
THOMAS CREEK	W	MAR 15	MAY 1	2
WILEY CREEK	W	MAR 15	MAY 1	2
SOUTH SANTIAM HATCHERY	S	JUN 1	FEB 1	2
CALAPOOYA RIVER	W	MAR 15	MAY 1	2
LEABURG HATCHERY	S	JUN 1	FEB 1	2
MCKENZIE RIVER	S	JUN 1	FEB 1	2
SANDY RIVER	W	FEB 1	MAY 15	2
SKAMANIA HATCHERY	S	JUN 15	JAN 15	2
SKAMANIA HATCHERY	W	JAN 1	JAN 15	2
HAMILTON CREEK	W	FEB 15	MAY 1	2
WIND RIVER	S	SEP 1	APR 1	2
HOOD RIVER	W	DEC 15	APR 15	1.5
KLICKITAT RIVER	S	JUL l	MAR 15	2
FIFTEENMILE CREEK	W	MAR1	APR 15	2
DESCHUTES RIVER	S	JUL 15	FEB 15	1.5
ROUND BUTTE HATCHERY	S	JUL 15	FEB 15	1.5
JOHN DAY RIVER	S	JUL 15	MAY 1	1.5
UMATILLA RIVER	S	JUL 15	APR 15	2

APPENDIX TABLE A9

Description of Study Area

DESCRIPTION OF STUDY AREA

The Columbia River and its tributaries drain on an area of 668,000 sq km (259,000 sq mi). This drainage basin includes almost all of Idaho, major portions of British Columbia, Washington, Oregon, and Montana as well as small sections of Wyoming, Nevada, and Utah.

The drainage basin of the Columbia River is divided by the Cascade Mountain Range Into an eastern and western region. The larger eastern basin is bordered by the Rocky Mountains on the east and the Cascade Mountains on the west. Much of this trough is filled with basaltic plateaus formed by prehistoric lava flows. The Columbia and its major tributary, the Snake, have cut major gorges and canyons through this formation. The smaller western basin lies In the trough between the Cascade Mountain Range and the lower Coast Range to the west. Here three major tributaries join the Columbia: The Cowlitz and Lewis Rivers from the mouth, and the Willamette from the south.

These two basins have different climatic and hydrologic characteristics. The eastern basin with its drier continental climate, receives most of its runoff from snow melt from April to July. The western basin with Its wetter climate receives most of its runoff from winter rains. Even though this basin occupies only 8% of the total Columbia River drainage area, it contributes about 24% of the total river discharge.

Dams have been built along the Columbia and its tributaries to minimize flood damage during peak runoff times, and to regulate water discharge for power generation and for irrigation. Fish ladders have been installed to allow anadromous salmon and trout to reach spawning grounds above most dams. High dams such as Chief Joseph Dam on the Columbia and

Hells Canyon Dam on the Snake are not passable, and thus cut off the fish from many miles of potential spawning and rearing habitat. Fish hatcheries have been built to compensate for this loss In fish production, but the majority of hatcheries have been placed in the lower reaches of the Columbia basin.